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ERRATUM.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

MARCH 1913.

GENERAL PHYSICS.

315. *Koschwitz Rectangular Glass Plate.* **K. Lüdemann.** (Zeitschr. f. Vermess. 41. p. 301, 1912. Zeitschr. Instrumentenk. 32. p. 388, Dec., 1912.)—Describes a glass plate made by Koschwitz, of dimensions 13 cm. × 18 cm., and on which is a rectangular network of lines 1 mm. apart, covering a space 11 cm. × 16 cm. The plate is intended to be used in measuring areas, and results may be obtained with it correct to about 1 in 1000. A. W.

316. *Electrical Measurement of Periodic Phenomena.* **G. Lippmann.** (Comptes Rendus, 155. pp. 1458–1460, Dec. 23, 1912.)—In place of the usual method for the comparison of two periodic phenomena by coincidences, an electrical contrivance is described which permits of at least as great accuracy, and at the same time is more rapid and is applicable to other problems where the method of coincidences is unsuitable. The apparatus is very simple, consisting merely of a rotating metallic arm carrying current to two contacts whenever it touches them. These contacts can be moved independently round the path of the rotating arm. Putting a telephone in series, one of these contacts is adjusted so that the sound of the contact is synchronous with one of the timepieces to be compared. Then the other contact is adjusted to be in time with the second timepiece. The path of the rotating contact is graduated, and the difference of angle between the two contacts, taken in relation to the known period of rotation of the central arm, gives the difference between the two timekeepers. The adjustment may be made to one-hundredth of a second. C. P. B.

317. *Determination of Poisson's Ratio.* **I. Williams.** (Phil. Mag. 24. pp. 886–891, Dec., 1912.)—In these experiments a steel beam of cross-section 2·49 cm. × 0·498 cm. is subjected to a uniform bending moment which causes its mean line to assume a longitudinal curvature 1/R. Then the cross-section assumes a transverse curvature, $1/R_1$, such that $R/R_1 = \sigma$, σ being Poisson's ratio (= lateral contraction/linear elongation). The longitudinal curvature is measured optically by a mirror fixed to the beam over one knife-edge. This

mirror was found to give accurately one-half of the curvature, a mirror on the other end being unnecessary. The first method of measuring R_1 was by attaching two mirrors opposite each other to the vertical sides of the beam. The relative angular movement of the sides is measured by the difference of the mirror scale-readings. The readings are interpreted by the relation $\sigma = \text{const.}\ D_1/D$, where D_1 and D = deflection on transverse and longitudinal scales respectively. With this method of attachment the scale of D_1 is only $\frac{1}{10}$ of that of D ; 8 values for σ were obtained lying between 0·265 and 0·280, mean value 0·273. To magnify the scale of D_1 a bifilar mirror suspension is used, a mirror being suspended by silk fibres from arms soldered to the sides of the beam and bent twice at right angles. The mirror is damped by a vane immersed in oil and protected from draughts by a case. The transverse scale is thus magnified in the ratio (= 20) of the height of the points of suspension above the beam to the distance between the threads. The 8 values of σ thus obtained vary from 0·2909 to 0·2932, mean value 0·2922. The max. difference from the mean is 0·44 %. E. J. S.

318. *Mechanical Properties of Solids and Liquids.* **A. Mallock.** (Roy. Soc., Proc. Ser. A. 87. pp. 466–478, Dec. 13, 1912.)—A paper discussing the various unclassified mechanical properties distinguished by the adjectives : Hard, soft, brittle, friable, tough, ductile, malleable, plastic (applied to solids) ; hard, soft, fibrous, granular, smooth (applied to surfaces) ; mobile, oily, viscid, frothy (applied to liquids). It is shown that all the above properties can be explained by the relations between (i) the absolute values of resistance to change of volume and change of shape, (ii) the volume limits and shear limits, (iii) forces belonging to the boundary surfaces (surface tension in liquids and forces of the same nature in solids). A. W.

319. *Stress Distribution and Manner of Failure in Sand Foundations.* **O. Strohschneider.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 299–336, Feb., 1912.)—Boussinesq has, from a consideration of potential in a body loaded at one point, obtained expressions for the horizontal and vertical components of stress at any point in the interior. These expressions are independent of the elastic constants for the material, so that it has only to be homogeneous in structure without of necessity being elastic. The present paper describes the direct determination of stresses in loose sand. The pressure is transmitted by a diaphragm placed at any desired point to a manometer. The latter is of the constant-level type, as a direct-reading instrument was found to allow sufficient movement to cause subsidence in the sand, vitiating the results. The vertical components observed are found to be consistently higher than those of Boussinesq, showing that, since their sum must in all cases equal the applied load, the stresses in sand do not extend to infinity on all sides of the loading axis. The author hence deduces an expression for the stress at any point by introducing into the analysis of Boussinesq the hypothesis that at any given depth below the load there is a range, subtending at the loading point with the axis an angle ϕ_0, beyond which there is no stress. The tests show that this expression is of the correct form for any given depth, but that ϕ_0 increases progressively with the depth, so that the envelope of the limiting ranges is a solid of revolution about the loading axis, whose surface is asymptotic to a horizontal plane at a depth H, below which the material becomes homogeneous and obeys the theoretical relations. It is found that $\sin \phi_0 = \rho_h/\rho_H$, where ρ_h and ρ_H are the densities of the sand at depths h and H, ρ_H being that of rammed sand.

Further, the increase of density ρ_h over ρ_0, that at the surface, varies as the weight of overlying sand $\int_0^h \rho_h dh$. The angle ϕ_0 is found by substitution of observed stresses in the empirical formula and ρ_0, ρ_h, and ρ_H are measured directly, whence H is calculated. For lightly packed sand foundations the limiting angle ϕ is found to be 50°–60°, H being about 1 m. Sand, like rigid bodies, will only withstand stressing up to a certain point, beyond which the subsidence suddenly increases. The resistance increases very rapidly with the area over which the load is distributed, varying as the third power of the diam. when a circular plate is employed. The resistance is also greatly increased by pouring on sand above the loading plate. In the equation of Boussinesq the stress varies inversely as the square of the distance from the load, from which it follows that at moderate depths the stresses, and hence the resistance, tend to become nearly constant. The results obtained confirm this tendency; with very thin layers of sand the influence of the underlying support is very noticeable, so that the resistance falls to a minimum at about 1·5 cm., then rises in a flat curve, which becomes nearly horizontal at 6 cm. Since sand is usually used to reinforce a weak subsoil it is necessary to proportion the depth of the former so that the latter shall not be overstressed, by using the empirical relation obtained. In a homogeneous elastic material, if σ_x and σ_z are the principal stresses, due to its own weight, at any point then $\sigma_x/\sigma_z = 2f^2 + 1 \mp 2f\sqrt{(f^2+1)}$, where f = the coefficient of internal friction, gives the condition for failure by shear slip. An analysis is made of the stresses on a material in these limiting conditions which are set up on the application of a single-point load. It is shown that approximately the principal stresses at any point lie along and perpendicular to the line joining the point to the application of the load. The lines of slip are plotted for these cases for a value of $f = 0{\cdot}7$ corresponding to an angle of repose of 35°. The intermediate case for a perfect fluid, when $\sigma_x = \sigma_z$ is also plotted, giving a series of concentric circles. Photographs of a section of loose sand during progressive loading show definite slip-lines obeying some law intermediate to those investigated, but rammed sand is not so satisfactory, this being attributed to the difficulty in ramming uniformly.

E. J. S.

320. *Determination Optically of Stress Distribution.* **E. G. Coker.** (Nature, 90. pp. 383–386, Dec. 5, 1912.)—The nature of stressing in simple structural members is now well known; but in most cases still to be investigated the stresses vary enormously from point to point. The author's well-known method of using the temporary double-refracting properties of stressed glass has enabled the stress at a point to be measured exactly. Glass is now replaced by one of the nitrocellulose compounds which is nearly as perfect optically, is not so fragile, and is much stronger in tension. With plane-polarised light the lines of principal stress are deduced from the map of isoclinic bands; hence the exact stress-distribution on the minimum section is set out. With circularly-polarised light the isoclinics are absent, enabling the colour-fringes indicating stress to be observed more accurately and to be calibrated from a wave-length or a colour scale. A zero method, which is easily manipulated, is to set a simple tension member along one principal axis and to stress it until the field is black at the required point. In many cases, *e.g.* the minimum briquette section, the minor principal stress is relatively small, and the experimental curve of principal stress-differences represents truly the end stresses, and those at other points nearly. The mean

minor principal stress is given by the difference between the mean height of this curve and the mean applied load stress. A very large polariscope, designed by the author and S. P. Thompson, is described. Light from a bank of lamps is diffused by tissue-paper and reflected by a black glass plate, set at the polarising angle, on to quarter-wave plates arranged to produce a circularly-polarised field. A thin glass plate analyser serves for qualitative, and a small nicol for quantitative work. This apparatus is used for models of ships and structures and has a clear field of 3 ft. × 1 ft. The results are shown for a long thin plate subjected to shear [see Abstract No. 776 (1912)]. The case of a conventional eye-bar is considered, a better design being suggested. The colour-fringes in a pair of spur wheels transmitting a heavy torque are also shown. E. J. S.

321. *Elastic Deformation of Water Conduits.* **G. Colonnetti.** (Accad. Lincei, Atti, 21. pp. 326–334, Sept. 22, 1912.)—Calculates the deformation of a water main when just filled, but not under pressure. Shows that the tube assumes an elliptical section, the dilatation of which is only half what it would be if the average hydrostatic pressure were distributed uniformly. This difference becomes less as the pressure is increased. E. E. F.

322. *Predetermination of the Stresses which will arise in Structures.* **Mesnager.** (Comptes Rendus, 155. pp. 1071–1072, Nov. 25, 1912.)—Describes the application to scale models of the well-known method of calibrating stresses in members of glass placed normal to a ray of plane-polarised light. The making of pieces such as I-beams by cutting from the solid glass is difficult and expensive, and causes unavoidable internal stresses which even annealing will not remove. If the components are cut from sheet and melted together residuary temperature stresses cannot be eliminated. The author has successfully used gelatine made soluble at the ordinary temperature to join the strips of carefully annealed glass. The cement is transparent and does not interfere with the optical properties of the glass. The slipping resistance, 0·5 kg. per sq. mm., is sufficient. Internal stresses in the models are very small, and their effect may be eliminated by using an unstressed model as datum. The points and magnitudes of max. stress, and the most unfavourable load-configuration were found in this way, with a model of scale 3 mm. to 1 m., for a bridge of 97 m. span with the arch encastré and partly solid with the deck. E. J. S.

323. *Mechanical Hardening without Deformation.* **Hanriot.** (Comptes Rendus, 155. pp. 1502–1504, Dec. 23, 1912.)—It has been shown previously that under certain conditions [see Abstracts Nos. 151, 325 (1913)] stretching may diminish mechanical hardness in spite of the fact that it increases the deformation. In order to study the possibility of hardening mechanically without deformation, a piece of annealed silver was compressed between two pistons in a cylindrical hole in a steel block. The silver squeezed out showed that the deformation only amounted to about 0·65 per cent., but the superficial hardness was increased from 23·5 to 39·5. In the centre the hardness was 38·7, but in spite of this uniformity the impression made by the ball was slightly oval. At the same time the strength had increased from 8·8 to 10·6 kg. per sq. cm. and the elongation had dropped from 18·3 to 10 per cent. Nevertheless, the specimen was slightly deformed, and consequently cubes of Ag, Cu, Al, Fe, brass, and Zn were subjected to a hydrostatic pressure of 10,000 kg. per sq. cm. All showed considerable signs of hardening, but

under the microscope the crystals were not deformed. Therefore mechanical hardening may be effected merely by compression without change of structure, and in itself is due to the deformation to which the metal has been subjected and not to the process of hardening. F. C. A. H. L.

324. *Hardness of Coins.* **T. K. Rose.** (Nature, 90. pp. 335–336, Nov. 21, 1912.)—The hardness defined as the resistance to permanent deformation is of the greatest importance in the process of minting, and is most readily determined by the Shore scleroscope. An annealed sovereign blank has a hardness of 25·5, which is increased to 50–53 on being struck. A sixpence has a hardness of 50, while a florin shows a value equal to 37. These values refer only to the "table" or flat portions of the coins, the raised portions of the design being much softer. In minting, the force of the blow appears to be expended almost wholly in the surface layers so that the centre of a coin is almost as soft as annealed metal. As a result the rate of wear increases during circulation. Tests have shown that the gold and silver trial-plates of the mint have, in the course of centuries, become almost completely softened at the ordinary temperature. The rate of softening is increased rapidly as the temperature rises. Softening is accompanied by a recrystallisation brought about by a change in the orientation of the molecules *in situ*. Gradual growth of the crystals occurs subsequently without much further softening. F. C. A. H. L.

325. *Stretching of Metals.* **Hanriot.** (Comptes Rendus, 155. pp. 971–974, Nov. 11, 1912.)—The indications of the physical state of a metal given by "ball hardness" are imperfect because of the modifications introduced by the pressure of the ball. Ingots of silver, brass, and aluminium have been cut into plates which were carefully annealed and rolled to various thicknesses in order to get various degrees of cold-working. Hardness tests and tensile tests were then made, after which the hardness was again determined close to the point of fracture. The results show that feebly-worked metals show almost the same tensile strength and elongation for all degrees of working although the hardness increases considerably with the degree of working. After a certain degree of working the strength increases rapidly. Up to this point, tests made after fracture show an increase of hardness, but above this degree of working, the stretch accompanying a tensile test actually diminishes the hardness. It would appear, therefore, that study of the tensile strength and elongation does not give all the information required about the physical state of a metal. They can, however, indicate whether or not a certain degree of working has been put upon the metal. Further tests on a 9 per cent. Al bronze, brass, and Al, show that mechanical hardening on stretching, as measured by increase of ball hardness, does not occur until the metal has been subjected to a permanent deformation. F. C. A. H. L.

326. *Elastic Hysteresis of Steel.* **B. Hopkinson** and **G. T. Williams.** (Roy. Soc., Proc. Ser. A. 87. pp. 502–511, Dec. 13, 1912. Engineering, 94. pp. 827–828, Dec. 13, 1912.)—Tests were made on steel with Hopkinson's alternating-stress machine and extensometer [see Abstract No. 628 (1912)]. The specimen is subjected to steady cyclical stress-variation of constant magnitude and within the elastic limit. The rise of temperature of the middle of the length over the ends, due to dissipation of energy by elastic hysteresis, becomes steady after 5 minutes' running and is observed by a

thermo-couple galvanometer coupled up by constantan wires. By averaging readings both ways external heat effects, such as those of eddy currents, are eliminated. The fall is about 10 deg. C. under 28 tons' range, and readings are correct to $\frac{1}{20}$ deg. C. Calibration is effected by passing alternating current through the specimen as it is held in the machine, the extensometer being removed. Simultaneous readings of a suspended-coil watt-meter, showing the energy dissipated over the effective length, and of the thermo-couple galvanometer enable the latter to be calibrated direct in ergs per cm.^{3} or in degrees of temperature, the former being most useful. Hysteresis losses at the higher stresses obtained at various times check to within 2 % to 3 % and increase roughly as the fourth power of the range. The loss under 39 kg. per sq. mm. (25,000 ergs per cm.^{3} per cycle) is of the same order as the magnetic loss in fairly strong fields. In neither case is any cumulative change in the properties of the material evident. Such a change is expected to be accompanied by a rise in the rate of energy loss but this is not found in the present tests at the highest range (45 kg. per sq. mm.) after $\frac{1}{4}$ million reversals in $\frac{1}{2}$ hour, though Stanton's results for the same metal indicate fracture after less than 100,000 reversals at 20 per sec. Hence it is concluded that there is some permanent effect which is negligible at high speeds. The existence of the elastic hysteresis stress-strain loop is demonstrated by a static test. The alternating-stress specimen is reduced to a cyclical state by alternate loading in tension and compression through the range, *e.g.*, 10 tons. The length is measured just after releasing 10 tons' compression, and then after applying and releasing 10 tons' tension; the difference is the intercept of the loop on the axis of strains. Assuming that the loop is lenticular and made up of arcs of circles, its area is $\frac{2}{3} \times$ length-difference $\times$ range. The hysteretic stress-difference (= length-diff. $\times$ E) is calculated on this assumption from the work per cycle as measured in the high-speed tests and is plotted against the range, being found to bear a nearly constant ratio, 0·8, to the statically determined difference. The ratio depends on the factor for the loop area, being 0·53 and 1·0 respectively for the limiting values, 1 and 0·5, of the latter. It is concluded that the hysteresis in cycles at 120 per sec. is less than in static tests but by not more than 30 %. The latter measurements are made with a modified Ewing extensometer having a tilting mirror. A control specimen was submitted to tensile load instead of compressive before taking the first reading. A second reading taken after the application and removal of the same tensile load showed a difference usually unmeasurable and never more than 10 % of that due to a full cycle from tension to compression. Hence the results show hysteresis effects truly to within 10 % or $\frac{1}{100}$ ton per sq. in. E. J. S.

327. *Theory of Beams.* **Hisely.** (Comptes Rendus, 155. pp. 953–956, Nov. 11, 1912.)—A vertical force, P, applied to a beam supported in any manner whatever, produces an effect e_P which may be a bending longitudinal thrust, or shear, causing a linear or angular displacement in any direction. If x be the abscissa of P's point of application and $y = F(x)$ be the equation of displacements for unit force, then $e_P = PF(x)$. A moment M, replacing P, is replaced by equal forces, P′ and P″, acting in opposite senses at points x and $x + \delta x$, where δx is small, and $M = P'\delta x$. Then $e_{P'} = -P'F(x)$ and $e_{P''} = P'F(x + \delta x)$, from which: $e_M = e_{P'} + e_{P''} = MF'(x)$. This relation means that the equation to displacements due to unit moment is given by the first differential of that for unit force. It is convenient to take the origin at one support, A, of a span $AB = l$ on which P acts at a distance $x = al$. Then

$e_P = Plf(a)$ and $e_M = Mf'(a)$. If the beam be free at A and supported in any manner at B, then $T_p = Plf(a)$ is the angular deflection at A. A moment M at A causes a deflection $T_M = Mf'(0)$. If the beam be now encastré at A, $T_p + T_M$ must $= 0$ and $M_A = -Plf(a)/f'(0)$ is the necessary moment. If T_p occurs at the end B, supposed free, then the moment for encastration at B is $M_B = -Plf(a)/f'(1)$. These formulæ enable an arc, articulated at the ends, to be encastré at both or one end. In a freely supported straight beam of constant section the slope of one end B is $T_p = Plf(a) = Pl \cdot l/6EI(a - a^3)$. Then $M_B = \frac{1}{2}Pl(a - a^3)$. The theory is then applied to the continuous beam.

E. J. S.

328. *Space-Time Manifold of Relativity: The Non-Euclidean Geometry of Mechanics and Electromagnetics.* **E. B. Wilson** and **G. N. Lewis.** (Amer. Acad., Proc. 48. No. 11. pp. 389–506, Nov., 1912.)—It is the purpose of this work to develop the four-dimensional non-Euclidean geometry which is demanded by the principle of relativity, and to show that the laws of electromagnetics and mechanics not only can be simply interpreted in this way, but also are for the most part mere theorems in this geometry. In the early sections the non-Euclidean geometry in two dimensions is developed in some detail and applications to problems in kinematics and mechanics are given. The sections on three dimensions are occupied largely with analytical developments of the vector algebra. Certain vectors of singular character are also considered. Passing to the case of four dimensions, further new types of vectors are met with and the new differential operator *quad* $\Diamond$ is used.

The science of electromagnetics is treated both from the point of view of the point charge and from that of continuous distribution. In both cases it is shown that the field of potential and the field of force are merely the geometrical fields previously mentioned except for a constant multiplier. Particular attention is given to the field of an accelerated electron, and here it is found that the vectors of singular properties play an important rôle. By a general treatment it is then shown that the conservation laws of momentum, mass, and energy are special deductions from a single general law stating the constancy of a certain four-dimensional vector or vectors of *extended momentum.* Finally it is pointed out that this last vector gives rise to geometric vector fields which can be identified with the fields of gravitational potential and gravitational force. Moreover it is shown that these fields are identical in mathematical form with the electromagnetic fields.

E. H. B.

329. *Linear Space-time Transformation.* **K. Kraft.** (Acad. Sci. Cracovie, Bull. pp. 952–968, Dec., 1912.)—The author considers an aggregate of all possible space-time co-ordinate systems, fulfilling only the condition that in each of them all the others appear in constant translatory motion. Concludes, without any further assumptions, that on suitably choosing the origins and units, each pair of systems conforms to the identity—

$$\varepsilon(x_1^2 + y_1^2 + z_1^2) - t_1^2 = \varepsilon(x^2 + y^2 + z^2) - t^2,$$

where t is constant throughout the aggregate. He does not decide as to the sign or magnitude of ε, and avoids Einstein's postulate of the constancy of the speed of light.

E. E. F.

330. *Uniform Rotation and Relativity.* **J. W. Nicholson.** (Phil. Mag. 24. pp. 820–827, Dec., 1912.)—In this paper, a formal examination is made of

the limits within which a correlation (as to rectilinear and rotational motions and the relativity principle) can be obtained on the ordinary analytical lines. It thus appears that a second-order correspondence cannot be found, so that the geometry of uniform rotation cannot be expressed in a simple general way. This is not an unexpected result, since rotation involves acceleration in a variety of directions, and the case of uniformly accelerated motion in one direction has not yet been so expressed. E. H. B.

331. *Theory of Gravitation.* **M. Abraham.** (N. Cimento, 4. Ser. 6. pp. 459–481, Dec., 1912.)—A more elaborate statement of the author's new theory of gravitation [see Abstract No. 785 (1912)]. He abandons Einstein's original postulate of the constancy of the velocity of light c, and considers it variable with the gravitational potential. In fact, he enunciates as his first postulate that the negative gradient of c indicates the direction of the gravitational vector. This postulate is shown to be implied in the equations of Lagrange. The second postulate maintains that "an observer belonging to the material system observed cannot ascertain any change in c. This means that the duration of any occurrence varies inversely as c, but does not exclude, for instance, the displacement of the sun's spectrum lines towards the red owing to its gravitational potential. Such a displacement has often been observed, but attributed to solar atmospheric currents or pressure." A third postulate says that "the forces acting on two bodies in equal gravitational fields are as their energies." This combines the conservations of mass and of energy into one law. Length is independent of c, and so is action, but mass varies as c^{-1}, as does time; and hence energy and force vary as c. Newton's law is inexact. It should contain a term inversely proportional to the cube of the distance, but in astronomy this term is negligible. E. E. F.

332. *Theory of Gravitation.* **G. Pavanini.** (Accad. Lincei, Atti, 21. pp. 648–655, Nov. 3, 1912.)—In Abraham's gravitational theory [see preceding Abstract] rigorous equations are given which have, however, a functional character depending on motions previous to the acceleration of two bodies. The author gives equations correct to the second order of the observation constant which have no functional complexities, and which bring out the difference between a propagation with the velocity of light and an instantaneous propagation. This difference takes the form of terms involving the inverse square of the velocity of light, and additional terms depending on the various elements of motion. E. E. F.

333. *Hayford Method of Gravity Reduction.* **W. Bowie.** (Washington Acad. Sci., Journ. 2. pp. 499–504, Dec. 19, 1912.)—The new method of reduction introduced by Hayford is based on the assumption that the earth's crust is in a state of approximate equilibrium called *isostasy*. The deficiency of density or material in the earth's crust under the land, and the excess under the oceans, is called the *isostatic compensation*. This compensation occurs, or is supposed to occur, within the upper portions of the earth's crust, and the depth to which it extends is called the *depth of compensation*. From the first investigation the most probable value for this depth was found to be 113·7 km. The 124 gravity stations in the United States have been arranged in groups according to the character of the topography surrounding the stations. The results indicate that there is no appreciable relation between the character of the topography and the gravity anomaly, and they also indicate that the earth's crust, under each class of topography, is in a state of

approximate equilibrium. Comparisons are then made between Hayford's reduction and the formulæ by Helmert; one of the tests is the value of the polar flattening of the earth as derived from stations in a limited area. This comes out as 1/298·3, which is in close agreement with other determinations. C. P. B.

334. *Relativity Principle and Law of Central Forces.* **Lémeray.** (Comptes Rendus, 155. pp. 1005–1008, Nov. 18, 1912.)—A mathematical paper deducing the inverse-square law for central forces due to electric charges from the principle of relativity. It is stated that for Euclidean space of n-dimensions the law would involve the $(n-1)$ power in agreement with what we know for tri-dimensional space. But this ordinary space is the only one in which there can exist a law of force satisfying the admitted principles, and a substance of which the density is proportional to the divergence of this force. [See Abstract No. 1112 (1911).] E. H. B.

335. *A. Einstein's Theorem.* **E. M. Lémeray.** (Comptes Rendus, 155. pp. 1224–1227, Dec. 9, 1912.)—In studying the case of a source of light which moves with respect to the observer, A. Einstein showed [see Abstract No. 133 (1906)] that the mass of the body diminished when it radiated energy. The present author gives a calculation leading to the result that the total energy radiated by a symmetrical radiator is the same, whether or not it is displaced relative to the observer. E. H. B.

336. *Geographical Position of Mecca and Jidda.* **N. Scheltema.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15, pp. 527–572, Nov. 28, 1912.)—Mecca is an important starting point for the study of Arabian geography, but accurate observations of its position have for long been impossible owing to religious difficulties. The present author, Consul for the Netherlands at Jidda, the harbour of Mecca, arranged for the necessary astronomical observations to be made in the sacred city by a young Mohammedan student, A. Salèm. Circummeridian altitudes were observed at Mecca and Jidda, and these observations, together with chronometer readings, compared with the British Hydrographic survey values of Jidda. Resulting position of Mecca (Kabah) is $\phi = +21^\circ\ 25'\ 18{\cdot}4''$; $\lambda = 39^\circ\ 50'\ 59{\cdot}2''$ (2h. 39m. 23·95s.), east of Greenwich. C. P. B.

337. *Determination of Relative Gravity in Tunis and Malta.* **A. Venturi.** (Accad. Lincei, Atti, 21. pp. 548–561, Nov. 3, 1912.)—Determinations of the value of g at three stations in Tunis, and in Malta, show that it is very slightly less than at Palermo, the results being Palermo, 980·086; Tunis, 979·955; Biserta, 979·993; Nabeul, 979·893; and Valletta, 979·905. W. H. Si.

338. *Brownian Motions and Probability Law.* **R. v. Ettenreich.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1163–1187, July, 1912.)—The theory of molecular collisions lies at the root of the derivation of the law of Brownian motions given by Einstein and Smoluchowsky [see Abstract No. 1909 (1905)]. This derivation handles the problem as a statistical one and treats it by the law of probability. In the present experimental determination an emulsion of mercury in water was adopted. The suspended particles were thus sure to be spherical, and their high density ensured their speedy passage out of the way. The chief conclusions are as follows:—(1) The distribution of the displacements corresponds to the probability law. (2) The mean square of displace-

ment is, within the limits of error, proportional to the displacement time, which accords with the assumption of a statistical source of the phenomena. (3) The vertical displacements are distinctly less than the horizontal ones. (4) The mean value of Loschmindt's number is $N = 82{\cdot}8 \times 10^{22}$. E. H. B.

339. *Application of Fourier's Theorem to Physical Problems.* **Rayleigh.** (Phil. Mag. 24. pp. 864–869, Dec., 1912.)—Deals with the difficulties arising in practical applications owing to an unnecessary degree of precision. Thus, in reflection, the aggregate reflection may be put $= C + iS$, where

$$C = \int_{-\infty}^{+\infty} \phi(v) \cos uvdv, \quad S = \int_{-\infty}^{+\infty} \phi(v) \sin uvdv \quad \ldots\ldots\ldots\ldots\ldots (4)$$

with $u = 4\pi/\lambda$.

In the converse problem we regard the reflection as given for all values of u and we seek thence to determine the form of ϕ as a function of x. By Fourier's theorem we have at once—

$$\phi(x) = \frac{1}{\pi} \int_0^{\infty} du[C \cos ux + S \sin ux] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

It will be seen that we require to know C and S separately. A knowledge of the *intensity* merely, viz. $C^2 + S^2$, does not suffice.

Although the general theory, above sketched, is simple enough, questions arise as soon as we try to introduce the approximations necessary in practice. For example, in the optical application we could find by observation the values of C and S for a finite range only of u, limited indeed in eye observations to less than an octave. If we limit the integration in (5) to correspond with actual knowledge of C and S, the integral may not go far towards determining ϕ. It may happen, however, that we have some independent knowledge of the form of ϕ. For example, we may know that the medium is composed of strata each uniform in itself, so that within each ϕ vanishes. Further, we may know that there are only two kinds of strata, occurring alternately. The value of $\int \phi dx$ at each transition is then numerically the same but affected with signs alternately opposite. This is the case of chlorate of potash crystals in which occur repeated twinnings. Information of this kind may supplement the deficiency of (5) taken by itself. If it be for high values only of u that C and S are not known, the curve for ϕ first obtained may be subjected to any alteration which leaves $\int \phi dx$, taken over any small range, undisturbed—a consideration which assists materially where ϕ is known to be discontinuous.

E. E. F.

340. *Basis of a Theory of Matter.* **G. Mie.** (Ann. d. Physik, 40. 1. pp. 1–66, Dec. 31, 1912.)—This is the third and concluding paper of a series on this subject [see Abstracts Nos. 782 (1912) and 18 (1913)]. It deals with the relation between inertia and weight, with the problem of the working quantum (*Wirkungsquantum*), and with gravitation. The analysis is four-dimensional and vectorial, but a few results may be noted. (1) Inertia mass and weight mass (*träge Masse und schwere Masse*), of a body are only completely identical when its elementary particles do not execute any internal motions. Hidden motions of these particles effect an increase of the inertia and a decrease of the weight. (2) The ratio of weight mass to inertia mass, consequently the so-called gravitation constant, is for every material a function of the tempera-

ture, which decreases with a rise of temperature. (3) The change of the gravitation constant with temperature is different in different materials, and is greater according as there is a greater part of the specific heat of the material corresponding to the kinetic energy of molecular motions. (4) Working at room temperatures, an experimental accuracy of 1 in 10^{11} or 10^{12} would be needed to detect the distinction between the values of the ratios, for different substances, of the weight and inertia. (5) The gravitation field is of one kind only and not of two as for magnetic and electric fields. (6) The interposition of one body does not affect the gravitational attraction of two others. (7) The motions of particles (or electrons) produce longitudinal ether waves or *gravitational radiation* (*Schwerestrahlung*), but at any frequency the intensity of such radiation bears to the corresponding light-intensity the ratio $1 : 8{\cdot}3 \times 10^{42}$! E. H. B.

341. *Air-resistance.* **W. König.** (Phys. Zeitschr. 13. pp. 1013–1016; Discussion, p. 1017, Nov. 1, 1912. Paper read before the 84. Naturforscher-versamml., Münster, Sept., 1912.)—Describes with diagrams various pieces of apparatus for determining wind-pressure, etc. To produce the air-blast a large tapering tube was used, which had a fan in the larger end driven by a motor placed some little distance away and coupled to it by a flexible shaft. It was found that for plates perpendicular to the direction of the air-current the pressure was proportional to the square of the velocity, but not quite proportional to the area of the surface. A large plate of double the area of a smaller one did not quite experience double the pressure. A special apparatus was used to investigate the vertical component of the pressure experienced by an inclined plate. Three different wind-velocities were employed, and all show a decided asymmetry when the vertical component of the pressure is plotted against the angle of tilt of the plate. In all three cases the max. vertical pressure is found when the plate makes an angle of 30° to 32° with the horizontal. Another piece of apparatus is designed to investigate the position of the centre of pressure. A. W.

342. *Suction behind Ships.* **Poincet.** (Comptes Rendus, 155. pp. 957–960, Nov. 11, 1912.)—A discussion of two series of experiments on a certain vessel shows that the results confirm those previously obtained in experiments on small models; hence it is possible to solve completely the problem of propulsion for the case of vessels with two lateral screws by means of experiments with small models. Suction and the effect of the wake are considered, and it is shown how these affect the efficiency of screws; the efficiency may, where cavitation does not take place, reach 70 %. A. W.

343. *Transition Layers and Surface Tension.* **R. D. Kleeman.** (Phil. Mag. 24. pp. 876–885, Dec., 1912.)—It requires the expenditure of energy to produce an increase in the area of surface of a liquid. The surface tension is therefore the work done, keeping the temperature constant, in producing unit increase in the area of surface of the liquid. Now this increase of surface may be produced in a variety of ways, since it follows from thermodynamics that the work done during an isothermal process between given limits is independent of the nature of the path of the process. One way suggested by Lamplace is to suppose a slab of liquid cut into two parts by an imaginary plane, and the parts then separated by an infinite distance from one another. If W denotes the total amount of work done during the process of separation, and A the amount of new surface formed, the surface tension λ_2 is given by

$\lambda_2 = W/A$...(1). If the distribution of the molecules in the new surfaces formed is the same as in the interior of the liquid, and the law of molecular attraction were known, the work done could at once be calculated. But the distribution of the molecules in the surface of a liquid is not the same as in the interior, a transition layer is formed in which the density changes continuously from that of the liquid on one side of the layer to that of the vapour on the other side. The nature of the effect of the formation of a transition layer on the surface tension can be easily investigated. Suppose that on separation of the two slabs of liquid in the foregoing process, no change takes place in the distribution of the molecules in the surfaces of the slabs. The work done, as before, is W. Now suppose the transition layers to be formed. This will require that the surface layer of the liquid undergoes expansion in different degrees in different parts. Since the complete process of increase of the surface of a liquid is a reversible one, we must suppose that the formation of the transition layer takes place in such a way that external work is done during the process, and that it is a reversible one. We may, for example, suppose that the liquid is contained in a cylinder in which the piston is in contact with the liquid surface in question exerting a pressure tending to prevent the formation of the layer. This work is done at the expense of the heat supplied since the temperature has to be kept constant during the process. Let w denote the amount of work in this case. The actual surface-tension of a liquid is then given by $\lambda_1 = (W - w)/A$...(2). Thus we see that the production of a transition layer on the surface of a liquid has the effect of decreasing the magnitude of the surface tension.

A formula is developed in this paper which expresses W in terms of quantities which can be measured. Since λ_1 can also be measured, the value of w can be calculated by means of equation (2). E. E. F

344. *Shape of Capillary Surface.* **A. Ferguson.** (Phil. Mag. 24. pp. 837–844, Dec., 1912.)—A theoretical examination of the shape of the capillary surface formed by the external contact of a liquid with a cylinder of large radius. It is hoped to use the formulæ thus developed in subsequent experimental work. E. H. B.

345. *Temperature Variation of Capillarity of Glycerine Solutions.* **J. Skala.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1213–1223, July, 1912.)—Following a new method, absolute measurements of the capillarity constant and its temperature-coefficient were made for various strengths of glycerine solutions. For pure glycerine a value was found for the capillarity constant of 63·89 dynes/cm. at a temperature of 18·8° C. The decrease of the constant with increase of the percentage of glycerine in solution does not follow a linear law. The temperature coefficient for pure glycerine is positive and decreases (within the limits of error) apparently proportionally with the percentage of water present until for a solution with 60 % glycerine (corresponding to a glycerine-water mixture containing 51·78 % recrystallised glycerine) the temperature-coefficient is zero, and the capillarity constant is independent of the temperature. Further addition of water gives the solution a negative temperature-coefficient. A. W.

346. *Change of Surface Tension of Mercury by Metallic Amalgams.* **F. Schmidt.** (Ann. d. Physik, 39. 6. pp. 1108–1132, Dec. 23, 1912.)—The surface tensions of pure mercury and of its amalgams were experimentally determined by Rayleigh's vibrating-jet method. The openings were of

elliptical section and the waves occurring in the streams issuing from them were photographed and evaluated. The chief results may be summarised thus :—(1) The metals Zn, Cd, Tl, Au, Sn, Pb, in the highest concentration tested, produced only a slight change in the surface tension of mercury. Zn, Cd, Tl increase the surface tension; Au, Sn, Pb decrease it. (2) The metals Na, K, Rb, Cs, Li, Ca, Sr, Ba, even in small quantities, cause a great change in the surface tension. Li, Ca, Sr, Ba increase, and Na, K, Rb, Sc decrease the surface tension. The first traces of the alkali metals have no effect; the greatest change occurs for a certain small concentration interval characteristic of each alkali metal. (3) The change produced in the surface tension of mercury is a periodic function of the atomic weight of the dissolved metal. (4) Metals occurring in the same group in the periodic system produce a change of the same sense. (5) For certain classes of metals, the higher the melting-point, the higher the surface tension of the amalgam. E. H. B.

347. *Bifilar Conical Pendulum Seismograph.* **C. Mainka.** (Phys. Zeitschr. 13. pp. 1206–1212, Dec. 15, 1912. From a paper read before the 84. Naturforscherversamml., Münster, 1912.)—Description, with illustrations, of a series of massively built conical pendulum seismographs, the smallest pattern carrying a weight of 135 kg., the largest 2000 kg. C. P. B.

348. *Work of the Reichsanstalt in* 1911. (Zeitschr. Instrumentenk. 32. pp. 119–135, April; 155–169, May, and pp. 195–210, June, 1912. Extract. Abstracts in Zeitschr. Elektrochem. 18. pp. 823–832, Sept. 15, 1912. Engineering, 94. pp. 766–767, Dec. 6, and pp. 802–804, Dec. 13, 1912.)—In the German report the work done in the various branches is reviewed; in the English abstract, some of the more interesting developments, particularly as regards the electrical work are briefly described. L. H. W.

349. *Liquid Films and the Foaming of Solutions.* **S. A. Shorter.** (Phil. Mag. 24. pp. 629–632, Oct., 1912.)—Gives an outline of a mathematical theory of the elasticity of liquid films which it is hoped may throw light on the process of foaming. [See Abstracts Nos. 189 (1907) and 1621 (1912).] E. H. B.

350. *Gyrostatic Action.* **J. W. Milnor.** (Phys. Rev. 35. pp. 477–483, Dec., 1912.)—Mathematical treatment of a general problem in gyrostatic action which includes the cases recently treated by Franklin and by B. L. Newkirk. [See Abstracts Nos. 469, 1484, 1808 (1912).] E. H. B.

351. *Equilibrium of the Circular-arc Bow-girder.* **A. H. Gibson.** (Roy. Soc. Edinburgh, Trans. 48. 20. pp. 391–416, 1912.)—The investigation enables a bow-girder to be designed as economically for distribution of material as the straight encastré beam. Quantitative data are calculated and plotted. E. J. S.

352. *Euler's Breaking Formula for Compound Bars.* **A. Lechner.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1189–1196, July, 1912.)—A mathematical discussion of the formula for a simple and a compound bar. E. H. B.

353. *Relativity Theory.* **J. Petzoldt.** (Deutsch. Phys. Gesell., Verh. 14. 23. pp. 1055–1064, Dec. 15, 1912.)—A quasi-philosophical discussion of relativity theory and its connection with other views of natural phenomena. E. H. B.

354. *Relativity and Gravitation.* **G. Nordström.** (Phys. Zeitschr. 13. pp. 1126–1129, Nov. 15, 1912.)—A highly analytical treatment with reference to Einstein's hypothesis which makes the speed of light depend on the gravitation potential. [See Abstracts Nos. 785 and 1175 (1912).] E. H. B.

355. *Relativity and Mechanical Views of Radiation.* **M. La Rosa.** (Phys. Zeitschr. 13. pp. 1129–1131, Nov. 15, 1912.)—Discusses the possibility of an experiment which would decide between the relativity principle and the dynamical or electromagnetic views of radiation of light. E. H. B.

356. *Correlation between Atmospheric Pressure and Rainfall in the East-Indian Archipelago in connection with the 3·5 Yearly Barometric Period.* **C. Braak.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 454–461, Nov. 28, 1912.)—Although the changes in the weather from day to day in the East Indies are very small there are large variations in the character of the seasons in different years. The author in the present paper puts forward the method of correlation as a possible help in forecasting the seasonal weather. Changes in pressure are considered to be hopeful for forecasting, while an important element from a practical point of view is the rainfall. Since a connection between the variations of pressure and rainfall may naturally be looked for, correlation coefficients have been calculated between the pressure at Port Darwin [see Abstract No. 789 (1912)] and the rainfall for certain groups of stations the observations from which are published by the Batavia Observatory. Monthly values are dealt with, the period used being 1883–1908. The coefficients for each month of the year and for each group of stations are set out in a table. Few of the coefficients exceed 0·5. The paper concludes with a discussion of the possibility of forecasting the pressure-changes. J. S. Di.

357. *On the Origin of Solid Precipitation.* **G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 46. pp. 1048–1050, 1912.)—Meteorological literature recognises two different kinds of solid precipitation, viz. ice stones and glazed frost. The former are frozen raindrops, hard as glass and transparent, and about 3 to 4 mm. in diam. They are not to be confused with hailstones nor with soft hail. Glazed frost is produced when supercooled raindrops strike any object. It forms a glassy ice surface which covers all objects exposed to the rain. On the morning of November 8, 1912, a form of solid precipitation occurred in Berlin which was different from either of the above. A snow shower was succeeded by the shower of solid precipitation, which lasted half an hour and was in turn replaced by a fine drizzling rain. The small pieces of ice, of which the precipitation consisted, were very irregular in shape, having many points and corners. They were hard and transparent, and may be described as ice-splints. The author explains the origin of the precipitation by supposing that the snow which was formed in a high and cold layer passed through a lower warm layer, was partially melted there, and finally traversed another cold layer at the surface in which it became frozen again. Observations by means of kites at the observatory at Lindenberg support this view, as a warm and humid layer was found there on that morning at a level of about 1000 m. R. C.

358. *Temperature Observations of Soil covered with Different Materials.* **P. Vujević.** (Meteorolog. Zeitschr. 29. pp. 570–576, Dec., 1912.)—At the Belgrade Meteorological Observatory, besides the other regular observations, the temperatures of the ground covered with small layers of

sand, limestone, moist soil, and grass were recorded. For these observations mercurial thermometers with cylindrical bulbs were employed in preference to the spherical form, since a greater part of the mercury contents coming into close contact with the soil, the true temperature of the latter is more accurately and quickly obtained. The instruments were shielded from the sun, and read hourly throughout the day and night. The material used by the author has been to a large extent hitherto unpublished for the years 1904 to 1906, and has been worked up by him; he has derived mean values for annual and diurnal range for each of the different surfaces. He considers his results more reliable for the summer months, since in winter the grass is withered and the snow can scarcely be completely removed from the turf soil. In the discussions, the temperature-differences of the other materials are constantly compared with regard to the sand-covered surface. It appears that the latter has always a higher temperature than the others, and the difference is much greater in summer than in winter, progressing regularly from Jan. to July and then falling off, its value being 20 times as much in summer (1·54°) as in winter (0·08°). In summer, on account of its low specific heat and the strong sunlight, the sand becomes much warmer than the other surfaces, whereas the feeble sunlight of winter produces but a slight effect. Tables are given of the deviation of the monthly means from the annual mean temperature of the three different surfaces; of the hourly variations from the mean of the month for April, July, and Oct.; of the night temperature for the summer months May and July; corrections for the elimination of the annual effort from the daily range of temperature for each month; and finally the daily range of temperatures at every hour of the 24 for each month for the three surfaces. The effect of evaporation in lowering the temperature between the hours of 11 a.m. and 6 p.m. is very evident, and the author has already dealt to some extent with this in a former paper. [See Abstract No. 442 (1912).] F. W. H.

359. *On Atmospheric Cooling and its Measurement: an Experimental Investigation.* **J. R. Milne.** (Scottish Meteorolog. Soc., Journ. 16. No. 29. pp. 9–17, 1912.)—The experiments discussed were made with a view to obtaining a satisfactory expression for the rate of loss of heat from a body maintained at a certain temperature and freely exposed to atmospheric influences. An instrument was devised to give a continuous record of this rate of loss of heat, and the records obtained are compared with simultaneous records of wind velocity and temperature (the latter being from a freely exposed bimetallic thermograph). A provisional formula is put forward connecting the rate of cooling with the wind velocity and temperature. Fairly satisfactory agreement is found between the values given by this formula and the actual values measured. The author hopes to continue the work, and when more data have been accumulated to establish a reliable formula for meteorological cooling. J. S. Di.

360. *Comparison Measures with Pyrheliometers.* **W. Marten.** (Phys. Zeitschr. 13. pp. 1212–1216, Dec. 15, 1912.)—In furtherance of the scheme proposed at the Innsbruck Conference of the International Meteorological Committee, and at the Oxford Meeting of the Solar Union, 1905, comparisons have been made between the solar constant given by Ångström's pyrheliometer and other standard instruments. C. P. B.

361. *Tidal Phenomena in the Western Mediterranean.* **R. v. Sterneck.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1245–1288, July, 1912.)—This work is in

extension of the researches by the author's father and himself on tidal phenomena in the Adriatic during the period 1904–7 [see Abstract No. 1578 (1908)], and after journeys in the spring of the years 1909, 1911, and 1912 to the coasts of the Western Mediterranean it became possible by means of his own observations and the data supplied by mareograms to prepare the present paper. The limited number of satisfactory observations available and the small range in variation of the water-level produced by the tides (often not more than 20 cm. and sometimes even less), the want of knowledge of the "establishment" times over wide areas, and the lack of self-registering instruments have all hitherto been difficulties in the way of forming a satisfactory theory of tidal phenomena in this sea. Grablovitz, however, in 1909 collected and arranged the hitherto available material in a most useful manner, and records of the mareograms at the Italian stations where the self-recording instruments were in use have been published by the Italian "Istituto Geografico Militare," whilst the author's own observations and determinations helped to fill up many of the principal gaps, and have thus enabled us to form a fairly complete representation of the course of tidal phenomena through the Western Mediterranean. After some preliminary remarks as to the method employed by him for the reduction of observations, the duration of time between the moon's upper and lower transits over the meridian and those of high and low water, together with explanation of the symbols employed, the author gives time and height of high water at syzygy for 50 Mediterranean stations. The existence of nodal lines, one between Corsica and the Balearic Isles, the other in the Tyrrhenian Sea, is confirmed and indicated in a chart accompanying the paper. From the formula $(2\pi/T)^2 = 8gh/a^2$, by insertion of determined values for the Tyrrhenian Sea he obtains the period T = 0·657 hour, and 0·670 for the sea north-west of Sardinia, 0·648 hour for the part to the south, these very short periods of oscillation having evidently no relation to the fundamental period of the tide itself (12·4 hours). The diurnal inequality is small and almost evanescent at the time of the equinoxes, but at other times of the year at full and new moon it has appreciable values. Almost all the mareographic records give evidence of the existence of the small secondary oscillations known as seiches, one whose period is 27·0 mins. and amplitude 2·5–10 cm. occurring at Barcelona, whilst at Palma a period of 18·6 mins. and amplitude 3–12 cm. exists, and at Mahon two alternating periods of 15·7 and 35·8 mins. with amplitudes of 1·5 cm. to 11 cm. occur, etc., the longest period of all observed being for Goletta in Tunis, where an oscillation having a periodic time of 45·0 mins. but with amplitude only 6–8 cm. was found. Tables of the results of the observations at Goletta, Nice, Marseilles, Cette, Valencia, and Alicante from the mareograms and at Barcelona, Palma, Port Mahon, and Oran from eye observations are given at some length, and finally a summary of results. The idea that there is a periodic ebb and flow through the strait between Sicily and Tunis is rejected as improbable. Besides the two regions with hypothetical closed nodal lines already referred to, there is a third which reaches from the Balearic Isles to Gibraltar and has a single east-west oscillation. In these three regions there can only exist forced oscillations under the influence of Sun and Moon, since, as calculation shows, the fundamental period is much shorter than 12 hours, and the general small amplitude of these is also an evidence of this, since it does not exceed 20–30 cm. F. W. H.

362. *Temperature Observations in Loch Earn.* **E. M. Wedderburn.** (Roy. Soc. Edinburgh, Trans. 48. 26. pp. 629–695, 1912.)—This paper deals with

observations undertaken with the view of determining the cause of the temperature seiche and the effect of varying meteorological conditions. For this a knowledge of the changes occurring at all points is necessary, and observations at frequent intervals at numerous depths and from several distinct regions of the lake are required. Loch Earn was chosen for the same reasons as weighed with Chrystal in his seiche investigations : the uniformity of the basin, its convenient size, and its accessibility, and also because the ordinary seiches had been so carefully investigated by him that it was hoped the loch would be found as well tuned for the temperature seiche. All the observations were made during Aug., 1911 ; five stations along the loch at distances of about 1½ miles from one another were selected, and 22 observers, including the author, were employed. It being found impossible to have regular hourly observations at each station, each observation consisting of the determination of temperature at eight or nine different depths, 2-hour observations were in general substituted, but as a rule regular hourly observations were kept during daylight at three of the stations. Observations were also made of the direction and velocity of the current at different depths by means of two Ekman current-meters, and the results are given in a table, but the author has not found it possible to draw any clear conclusions from them. The temperature observations at various depths from 0 to 60 m. below the surface at the five stations are recorded at full length, and diagrams illustrating some of the results are also given. These diagrams show that in the earlier part of the month there was a well-marked oscillation of the isotherms, and that the phases of the oscillations at stations I and II were the same, and directly opposite to those at IV and V. At station III (middle of lake) they are different in character and much shorter in period. Thus it is clear that the seiche theory of the oscillations is the true one, the long-period oscillations being absent at III on account of the proximity of the "uninode." Thus temperature seiches do exist, and are of the nature of a standing boundary wave. Winds of even very moderate strength will start oscillations, and examples of oscillations forced by wind have been obtained. The author gives a discussion of the hydrodynamical theory of temperature oscillations, and he finds the whole theory to depend on the differential equation $\partial^2 P/\partial v^2 + n^2 P/g\sigma(v) = 0$, where $u = \Sigma P \sin n(t - \tau)$, P is a function of v alone, and T is constant. The methods used by Chrystal are thus available here. Calculations of the period for Loch Earn by approximate methods are next made, and the results given by means of a table and diagram. With certain assumptions a period of 14·99 hours was obtained, agreeing closely with the observed period of 15·2 hours (for 1 p.m. on Aug. 8), whilst for Aug. 15 the observed and calculated periods were found to be 14 and 13·8 hours respectively, the binodal period under the same conditions being 8·44 hours calculated and 8·2 hours observed, the ratio of the two observed values 15·2/8·2 = 1·79 being thus greater than for the ordinary seiche, though theoretically it should be nearly the same ; and the author attributes the discrepancy to the less accurate nature of the assumptions on which the theory rests for the "higher nodalities." [See also Abstract No. 587 (1911).] F. W. H.

363. *Attraction of Sun-spots for Prominences.* **F. Slocum.** (Astrophys. Journ. 36. pp. 265–268, Nov., 1912.)—Examination of a series of spectroheliograms taken during the life of the large group of sun-spots visible during Aug., Sept., and Oct., 1910, showed evidences of very considerable activity both in the spot form and the neighbouring prominences when the spot was near the limb. Bright eruptions were constantly appear-

ing and disappearing, and on several occasions dark flocculi were observed in the vicinity. Photographs taken on Oct. 8 are reproduced to illustrate several of the more interesting changes. The most striking feature is that the prominences are seen to be pouring from both sides apparently down into the large spot. Measurements on recognisable features of the prominence matter gave velocities along the trajectory of 16, 20, and 60 km. per sec., at distances of 170,000, 130,000, and 75,000 km. from the centre of attraction. In some few cases there also appear to be evidences of repulsion. Hale and Evershed have previously given instances of gaseous matters exhibiting tendencies to move towards the sun-spot vortices, but their results indicated diminishing velocities as this centre was approached, whereas these by Slocum indicate acceleration towards the centre. C. P. B.

364. *Motion of Solar System.* **W. H. Pickering.** (Roy. Astronom. Soc., M.N. 72. pp. 740-743, 1912.)—Several facts point to the probability of the existence of an interstellar absorbing medium. The present note deals with the motion of the solar system relatively to such a medium, which may be simply the ether or that with some gaseous product. Attention is devoted specially to the comets, moving as they do throughout vast regions from the immediate neighbourhood of the sun to the farthest boundaries of the solar system. If there be an absorbing and resisting medium, then as the mass of a comet is much less in proportion to its surface than that of the sun, the aphelia of all comets of long period would tend to fall behind the sun in its path, and should be concentrated towards the anti-apex. A diagram is given showing the longitudes and latitudes of the aphelia of all the parabolic orbits, and it is evident that the aphelia of the brighter comets show a definite concentration in certain regions, notably near the position $\lambda = 97°{\cdot}2$; $\phi = -16°{\cdot}3$ (sun's anti-apex is $\lambda = 90°{\cdot}5$; $\phi = -34°{\cdot}3$). The difference might be caused by (*a*) the absorbing medium not being stationary with regard to the stars as a whole, or (*b*) by the sun moving in a curve instead of a straight line. Confirmation of or distinction between these possibilities requires further observations, but there appears to be evidence that the solar motion relatively to the resisting medium differs somewhat in direction, but not very greatly, from its motion relatively to the stars. C. P. B.

365. *Constitution of Solar Corona.* **J. W. Nicholson.** (Roy. Astronom. Soc., M.N. 72. pp. 729–739, 1912.)—Further examination of the corona spectrum on the theory developed by Planck and others [Abstracts Nos. 341, 1643 (1912)] leads the author to find theoretical constitutions of atomic arrangements accounting for many of the lines. A complete analysis of the investigation is given, with a table showing the electronic compositions for each line recognised ; also a list of 13 lines which are still unexplained, the most important of these being $\lambda 5303$, $\lambda 4566$, and $\lambda 4359$. An interesting fact is noted, namely, that the cube roots of the wave-lengths of three of the most important lines, 5303, 4359, 3534, have constant differences, so that they probably have a like origin. C. P. B.

366. *Variations of Solar Spectrum Wave-lengths.* **A. Perot.** (Journ. de Physique, 2. Ser. 5. pp. 975–986, Dec., 1912. Paper read before the Soc. franç de Physique, June 7, 1912.)—From the results of an investigation of the rotation period of the sun by means of radial velocities from spectographic observations at the limb, various workers have formulated an empirical law of rotation with the solar latitude as one argument. By

considering the velocity in km. instead of angular movement, the author finds it possible to express the velocity of rotation at any latitude as a function of the latitude, together with a small reduction constant; this strongly suggests the idea that the rotation velocity observed is the resultant of the rotation of a solid body and a constant retardation component *independent* of the latitude. He next describes a powerful spectograph with interferometer attachment for a rigid determination of the rotation period, and of the peculiar augmentations of wave-length shown by spectrum lines at the solar limb, which have been ascribed to the effect of pressure in the reversing layer. This augmentation of the wave-length exists all round the disc, and is apparently independent of the solar rotation; it has also been supposed to be due to anomalous dispersion of the light passing through the denser layers of the solar atmosphere. A possible explanation is suggested involving the action of the descent of electrons into a layer of rotating gas. The movements at the surfaces of interaction might conceivably be of the nature suggested by the rotational vortices discovered by Hale, and proved to be regions with magnetic fields. The helical motions of many prominences mentioned by Deslandres also suggest the interaction of electrons with a magnetic field. C. P. B.

367. *Magnetic Field in Solar Atmosphere.* **H. Deslandres.** (Comptes Rendus, 155. pp. 1573–1581, Dec. 30, 1912.)—The author gives a long discussion of the evidence for the existence of a magnetic field in the higher solar atmosphere. Certain prominences have been observed to have a distinct helicoidal structure, very similar to what would be expected in the case of an ion projected into a magnetic field, and a phenomenon easily reproduced experimentally. Drawings are given showing the probable deviation of the prominence matter in the direction of the sun's rotation, and the resulting differentiation of the absorption phenomena at the east and west limbs. C. P. B.

368. *Origin of Planets and Satellites.* **K. Birkeland.** (Comptes Rendus, 155. pp. 892–895, Nov. 4, 1912.)—Based on his experimental researches on the forms assumed by various types of kathode discharge, the author suggests that many of the phenomena of the solar system may be due to the action of electromagnetic forces of the same order of magnitude as gravitation. It is probable that the particles of matter driven off, from the sun say, carry with them a positive charge, and the research follows to some extent the idea of determining the paths of such particles when subjected to the action of magnetic or electrostatic fields. There thus would be produced in the equatorial magnetic plane of the sun a series of limiting circles, about which the emitted particles would accumulate. Mention is also made of the possible production of heat by kathodic disintegration, and the similarity to the process of evolution of β- and α-rays from radio-active bodies. **C. Störmer.** (Ibid. pp. 1073–1075, Nov. 25, 1912.)—Störmer refers to his own suggestion of the same explanation in 1907 [Abstract No. 1327 (1911)], and gives some formulæ in comparison with the results indicated by Birkeland for the trajectories of the charged particles. **K. Birkeland.** (Ibid. pp. 1467–1470, Dec. 23, 1912.)—In continuation the author considers the result of the emission by the sun of the charged particles to be that the body becomes negatively charged. A photograph is reproduced showing the type of discharge produced from a kathode 24 cm. diam., feebly magnetised, with a continuous discharge of 100 milliamps. Another figure shows

the effect of disruptive charges, with rotational movements in opposite directions in the two hemispheres, very similar to the vortices found by Hale in sun-spot areas. C. P. B.

369. *Transit of Mercury, November* 14, 1907. **N. Donitch.** (Acad. Sci. St. Pétersbourg, Bull. 17. pp. 1011-1030, Dec. 1, 1912.)—On account of the difficulty experienced in obtaining records of the spectrum of Mercury under ordinary conditions, advantage was taken of its passage across the sun's disc on Nov. 14, 1907, to secure a series of photographic spectograms, special attention being devoted to the two positions of internal contact. The observations were made at Assouan, in Upper Egypt. After a short *résumé* of the history of the phenomenon, first observed by Gassendi in 1631 at Paris, a description of the apparatus employed on the author's work is given. This consisted of a Zeiss objective, 10 m. focal length, giving an image of the sun about 9·5 cm. diam., and an image of Mercury about 0·5 mm. diam. at the primary focal plane. During the exposures the objective was diaphragmed down to 5 cm. The diurnal motion was compensated by an electrically-controlled Lippmann cœlostat, with a secondary mirror to keep the reflected beam in the meridian. In order to obtain a magnified image on the slit an enlarging lens of 285 mm. focal length was employed. The spectroscope had a single Zeiss prism of 60° angle, with camera lens of 273 mm. focal length. A long discussion is given of the means adopted for determining the changes of intensity of the spectrum lines over the image of the planet, with the conclusion that it is doubtful if an atmosphere extends as high as 15 km. from the planet's surface. C. P. B.

370. *Satellite Systems of Planets.* **E. Belot.** (Comptes Rendus, 155. pp. 1471–1473, Dec. 23, 1912.)—The general hypothesis is formulated that the satellite system of planets consists not only of the detached satellites, but also includes the masses condensed along the equatorial regions, and only prevented from becoming separated by the resistance of the medium and the attraction to the centre. This view appears to be verified by the known fact that the equatorial zones of the bodies of great mass (Sun, Jupiter, Saturn) rotate more rapidly than the other regions ; also by the relatively low density of the surface materials of the planets compared with the density of the isolated satellites. C. P. B.

371. *Spectrum of Comet Gale* (1912*a*). **P. Idrac.** (Comptes Rendus, 155. p. 896, Nov. 4, 1912.)—Photographic observations of the spectrum of Comet Gale (1912*a*) were obtained at the Meudon Observatory with a prismatic camera [Abstract No. 1086 (1910)] attached to the 8-in. equatorial. The plates show the characteristic cometary spectrum consisting of the radiations of hydrocarbon and cyanogen. C. P. B.

372. *Photographs of Nebulæ and Star Clusters.* **H. D. Curtis.** (Lick Observatory, Bull. No. 219. Nature, 90. p. 341, Nov. 21, 1912. Abstract.)—The paper gives a detailed description of 132 objects photographed with the Crossley Reflector at Lick Observatory. Attention is drawn to the additional information given by the photographic records. C. P. B.

373. *Darkening at the Limb in Eclipsing Variables.* **H. N. Russell** and **H. Shapley.** (Astrophys. Journ. 36. pp. 239–254, Oct., 1912.)—Up to the present time the problem of determining the orbital elements of an eclipsing

binary from the light-curve has been investigated on the assumption that the stars are without appreciable absorbing atmospheres. In this paper the authors continue the method outlined previously [Abstracts Nos. 203 (1911), 1664 (1912)] for introducing the varying brightness from limb to centre into the discussion, and give formulæ and reduction tables for total eclipsing conditions. (Ibid. pp. 385–408, Dec., 1912.) Extends the analysis to the cases of annular and partial eclipses. C. P. B.

374. *Study of Scintillation.* **C. Gallissot.** (Comptes Rendus, 155. pp. 1134–1136, Dec. 2, 1912.)—Scintillation of stars is manifested by rapid changes of brightness accompanied in most cases by changes of colours. This is found to influence the estimation of star magnitudes, and the effect is different for different colours. C. P. B.

375. *Influence of Colour and Magnitude in Stellar Photometry.* **C. Gallissot.** (Comptes Rendus, 155. pp. 1590–1592, Dec. 30, 1912.)—In the estimation of the relative brightness of luminous areas Broca and Sulzer found interesting differences introduced when the illumination was variable; the Purkinje phenomenon diminished when the areas were diminished in diam. The effect is of importance in the estimations of stellar photometry owing to the presence of more or less scintillation when working with small instruments or the naked eye [Abstract No. 674 (1910)]. Measurements have been made with white light, and with coloured lights obtained by selecting regions of the spectrum by coloured screens. In the case of short illuminations separated by intervals of 1 sec., the brightness was almost always estimated as fainter than when the light was steady. This error of estimation for a given duration of illumination increases when the actual brightness diminishes and more rapidly for blue radiations than for red. [See preceding Abstract.] C. P. B.

376. *Yerkes Actinometry.* **J. A. Parkhurst.** (Astrophys. Journ. 36. pp. 169–227, Oct., 1912.)—The main object of the investigation was the co-ordination of the visual and photographic magnitudes of stars, the present paper dealing with the measurement of the stars of the Potsdam Photographic Durchmusterung from $+73^{\circ}$ to $+90^{\circ}$ declination. The observations were made on photographs taken with a Zeiss doublet lens of 14·5 cm. aperture, 81·4 cm. focal length, furnished with an objective prism of the same aperture and 15° angle. The method of extra-focal image diameters was used for the determination of photographic magnitudes. These values were corrected for the colour-curve of the lens. For the magnitudes on the visual scale, focal-plane images were taken on colour-sensitive plates with a specially designed and corrected filter. The differences between photographic and visual magnitude are classified with the type of spectrum as given by the Harvard system. C. P. B.

377. *Spectrum of β Scorpionis.* **J. C. Duncan.** (Lowell Observatory, Bull. No. 54. Nature, 90. p. 394, Dec. 5, 1912. Abstract.)—From a series of new measurements of the radial velocity of this interesting spectroscopic binary it is found that the values given by the calcium (K) line are distinctly abnormal compared with the velocity given by other spectrum lines. A similar phenomenon has been noted by Hartmann in the case of δ Orionis, and it has been suggested to be due to the presence of cosmically-distributed calcium vapour between the earth and these stars. C. P. B.

378. *Spectrum of Nova Geminorum* (1912). **W. S. Adams** and **A. Kohlschutter.** (Astrophys. Journ. 36. pp. 293–321, Nov., 1912.)—The first observations of the spectrum of Nova Geminorum (1912) were made on March 22, nine days after its discovery by Enebo. All the photographs were obtained at the 80-ft. focus of the 60-in. reflector and Cassegrain spectrograph at the Mount Wilson Observatory, California. At first a single prism of 63° angle with a camera lens of 102 cm. focal length was used; after April 5 this lens was replaced by one of 46 cm. focal length. Fourteen photographs of the spectrum of the Nova were obtained from March 22 to May 27, 1912. During the early stages of the life of the star the spectrum consisted of numerous broad bright bands, with strong continuous spectrum and many dark lines, the most prominent of these latter being situated on the more refrangible edges of the hydrogen lines. Each of the hydrogen bands showed multiple structure similar to that observed in previous Novæ spectra. The rapid changes in the spectrum from night to night are well shown in a series of spectra extending from March 22 to Aug. 19, reproduced with the paper. Towards the later stages the lines characteristic of nebulæ became conspicuous, the lines of helium, etc., which had been very strong during the intermediate stages, becoming evanescent.

Special attention was devoted to the determination of the radial velocity of the system, the measurements being made on the narrow absorption lines of calcium (H and K), some faint lines of iron, and the narrow sodium lines D_1D_2. The adopted velocity is given as +10 km. per sec. Attention is drawn to the latest phase of the spectrum, which in some respects resembles that of the Wolf Rayet star spectrum, and one of these spectra is shown for comparison. A long list of wave-lengths is given for the lines measured in the spectrum from λ3883 to λ6677, with the probable origins of as many as could be identified. As the component lines varied greatly from time to time, any detailed reference to these can only be of value in comparison with the photographs of the spectra. With the idea of detecting any possible polarisation in the spectrum lines, two spectrograms were obtained on April 7, using a Nicol prism and a quarter-wave plate in front of the slit; no displacements of the bright maxima were discernible on rotation of the quarter wave-plate. C. P. B.

379. *Constants for Two Star-streams.* **J. C. Kapteyn** and **H. A. Weersma.** (Roy. Astronom. Soc., M.N. 72. pp. 743–756, 1912.)—Details are given of the formulæ used in the determination of the elements of the two great star-streams outlined in lectures given by Kapteyn at St. Louis in 1904, and in South Africa in 1905. Very much simplified solutions have been published by Eddington, Dyson, and Schwarzschild, but they base their derivations of the stream elements exclusively on the *number* of proper motions in different position angles, whereas in the method of Kapteyn the *amount* of the proper motion is considered in addition. C. P. B.

380. *Elements of the Eclipsing Variables W Delphini, S. Cancri, SW Cygni, and U Cephei.* **H. Shapley.** (Astrophys. Journ. 36. pp. 269–285, Nov., 1912.)

381. *Identification of Small Planets.* **L. Fabry.** (Comptes Rendus, 155. pp. 946–948, Nov. 11, 1912.)—A short analysis is given of a method of quickly examining the reduced positions of any minor planet observed, so that it may be at once ascertained whether it is one already known, or is a new discovery. C. P. B.

LIGHT.

382. *New Bar Photometer for Measuring Densities by Non-parallel Rays.* **W. B. Ferguson.** (Photographic Journ. 52. pp. 283–287; Discussion, pp. 287–290, Nov., 1912.)—The researches of A. Callier, F. F. Renwick [Abstracts Nos. 1273 (1910), 1351 (1912)], and others have shown that there is no such thing as one true value for the density of a granular silver photographic deposit, but that the value of the density of a photographic plate depends on the set of circumstances in which it is measured; the very different values obtained for the same deposit, when observed in different photometers, due to the different amounts of scatter in each case, have led to the conclusion that the most useful method of density measurement is one in which the max. amount of scatter is produced by making the measurements with the film in contact with opal glass, or some similar diffusing medium which is placed between the film and the source of light. The value of the optical density to non-parallel rays ($D\not\parallel$) so obtained is applicable to contact printing, and differs but little from the true photographic density ($D\phi$) obtained by Renwick's method. The special points in the new photometer are: Its readings depend merely on the law of inverse squares and such measurements as can be taken off a metre rule. It is not a comparator, and its accuracy does not depend on the previous calibration of a wedge. The results obtained are free from any varying error due to scatter such as occurred in the Hurter and Driffield instrument. There is no variation in the comparative intensity of the two lights used, both being run in parallel off the same electric circuit. There is no screen between the plate and the observer. The matching of two illuminated patches always takes place at the same intensity, and is thus rendered easier to the eye, while by the simple device of a compensation screen the two patches are rendered of the same tint. There is no uncertainty due to the use of polarised light: an objection which has been raised against the Hufner and Marten forms of photometer. It will measure the smallest densities with an accuracy which depends solely on the eye of the observer. Any part of the plate can be measured. By the substitution of an Abney screen and the removal of a diffusing plate, it may be used for measuring densities in parallel light ($D\parallel$). It is simple in design, inexpensive to construct, and is easily put in adjustment for use. In the *discussion*, **Chapman Jones** pointed out that the arrangement was practically the Abney screen as modified by the use of opal glass, but with the positions of the plate to be measured and the opal reversed. The author said the abolition of the translucent part of the Abney screen got rid of the objection which had been raised, that in the case of that screen what was measured was the opacity of a piece of paper modified by placing a negative in front of it, and the results were rendered erroneous by mutual reflection between the negative and the paper *after* the light had passed through the negative. Any reflection which takes place in the new instrument happens *before* the light passes through the negative, and would not affect the result. A. E. G.

383. *Grating Spectrograph.* **L. Geiger.** (Ann. d. Physik, 39. 4. pp. 752–788, Nov. 12, 1912.)—Describes a grating spectrograph in which no glass is used, and its use for photographing lines in the ultra-red iron spectrum. Light from a slit falls on a small plane mirror (M_1) and is thence reflected at

right angles on to a second mirror (M_2), which has a silvered spherical surface of about 85 cm. radius of curvature, the diam. of the mirror being 9·6 cm. This mirror renders the light parallel, and the light is then allowed to fall on the plane reflecting grating 5 cm. × 8 cm., with 14,438 lines to the inch. The angle of incidence of the central ray of the diverging beam falling on M_2 is about 10°. The grating is mounted on a graduated circle. The light from the grating after reflection from M_2 converges to give a spectral image on the photographic plate. A slight adjustment of the mirrors allows the light reflected from M_2 to miss the small mirror M_1. The arrangement is shown to be stigmatic and gives strong illumination. A full discussion of details is given; 216 lines of the iron spectrum, from λ6750 to λ9809, were photographed; the error in the wave-lengths is calculated to be not more than 1/100 Å. A. W.

384. *Refractometers.* **T. M. Lowry.** (Phys. Soc., Proc. 24. pp. 400–404, Oct., 1912.)—A paper discussing some points in the use and design of refractometers. The ordinary standard wave-lengths (Na D-line, C, F, and G lines of hydrogen) have several disadvantages. It is suggested that a much better series would be Li 6708, Na 5893, Hg 5461, Hg 4359, as used previously by Dorn and Lohmann in their measurements of the refractive indices of liquid crystals. The author has found that, in the case of a large number of simple organic compounds, the optical and magnetic rotatory dispersions may be expressed by simple formulæ of the type $a = a_0/(\lambda^2 - \lambda_0^2)$. In this equation the absolute optical or magnetic rotatory power of the substance is expressed by a single constant a_0, whilst the rotatory dispersive power is expressed by a second constant λ_0. Thus, in this case, the actual wave-lengths employed in determining the constants are of little importance, as any suitable pair should give the same result. Refractive dispersion is more complex, but measurements appear to be of little use until we possess more knowledge of the dispersion law for typical organic compounds in the infra red, visible, and ultra-violet regions of the spectrum. Gifford's experiments have shown marked variations of refractive index in prisms of the same glass, even when taken from the same melting. Hence refractometers need to have their tabulated data checked. The most convenient method is by means of a piece of quartz, cut so as to give both the ordinary and extra-ordinary ray; fluorite, calcite, and silica may also be used. The following table gives the refractive indices, determined by Gifford, for these substances for various Li, Cd, and Hg lines:—

λ.	Fluorite.	Quartz. (Ordinary Ray.)	Quartz. (Extraordinary Ray.)	Calcite. (Ordinary Ray.)	Calcite. (Extraordinary Ray.)	Vitreous Silica.
6708 Li	1·43226	1·54146	1·55047	1·65367	1·48427	1·45607
6438 Cd	——272	——231	——135	——503	——468	——677
5461 Hg	——499	——617	——534	——165	——789	1·46015
5086 Cd	——619	——824	——748	——527	——954	——190
4800 Cd	——691	1·55013	——945	——861	1·49110	——357
4359 Hg	——952	——380	1·56323	1·67518	——410	——674
4046 Hg	1·44153	——715	——671	1·68134	——691	——968

From these data it is possible to deduce the refractive power of a liquid from the angular readings of the refractometer for the new series of wave-lengths.

The trouble of calculating may be avoided by using the correction curves reproduced in the paper, and which were worked out by F. Tinker. The water-jacketing usually supplied with the Pulfrich refractometer appears to be very inefficient, and gives rise to such large possible temperature-differences that all measurements made with this instrument in the higher ranges of temperature can scarcely be trusted. A refractometer prism, with water-jacket designed to overcome the defects of the Pulfrich instrument, has been constructed, but no tests have as yet been made with it. A. W.

385. *Self-testing of Dispersion Apparatus.* **C. V. Burton.** (Nature, 90. pp. 435–436, Dec. 19, 1912.)—In testing a plane grating, echelon, or other dispersive apparatus by the usual method of crossing its dispersion with that of an auxiliary piece, unless the resolving power of the auxiliary dispersion is in some degree comparable with that of the piece to be tested, it is scarcely possible to identify ghosts which lies close to their primaries. The author suggests that the difficulty may be removed by using an arrangement of two front-reflecting mirrors to cross the echelon, say, with its own dispersion. One of the mirror faces has one truly straight edge, at which the dihedral angle, in contact with the face of the second mirror, is 90° or less. The two mirrors are set exactly at right angles to one another, and placed so that their line of contact is inclined 45° to the horizontal, while the vertical plane through the line of contact bisects externally the angle between the mirrors. The light would thus pass successively through a slit (shortened to a minute square), an objective, the echelon, and after reflection at the mirrors would return through the echelon and objective and be brought to a focus in the plane of the slit. An accurately right-angled prism with reflecting faces meeting in a sharp line could be substituted for the pair of mirrors. The suggested arrangement could be modified by allowing the beam to pass through a second lens and be brought to a focus, being then reflected by a small right-angled prism through the whole system; but this necessitates four transmissions through objectives. A similar arrangement may be employed for echelon gratings of reflecting type. A. W.

386. *Imitation of Double Refraction by Glass Plates.* **E. Terlanday.** (Ann. d. Physik, 39. 6. pp. 1207–1229, Dec. 23, 1912.)—Doubly-refracting crystals are imitated by a pile of glass plates placed obliquely, various angles being tried. In some cases two polarised beams are obtained as well as one unpolarised, three in all. The possible constitution of crystals is discussed at some length, reference being made to certain models of constituent parts grouped in different fashions. It is concluded that in such models, the form of the intervals, the density of the material in these intervals, and the dimensions all have an effect on the result. E. H. B.

387. *Indices of Doubly-refracting Crystals by Displacement Interferometry.* **C. Barus.** (Phil. Mag. 24. pp. 827–837, Dec., 1912. Abstract of Report to Carnegie Inst. of Washington.)—Describes the arrangements used and examines the order of accuracy obtainable. The interferometer was an improvised apparatus made of $\frac{1}{4}$-in. gas pipe through which water continually circulated. It is claimed that μ—1 was measurable with an accuracy of one part in a million. [See Abstract No. 1831 (1912).] E. H. B.

388. *Double Refraction of Unannealed Glass.* **H. Schulz.** (Phys. Zeitschr. 13. pp. 1017–1028; Discussion, pp. 1028–1029, Nov. 1, 1912.

Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—A method is described whereby the strain (due to cooling) in glass plates may be investigated and measured. Light from a mercury lamp passes first through a monochromator, and light of known wave-length thus falls on a slit, then in succession passes through a convex lens, a polarising nicol, a Soleil-Babinet compensator, a diaphragm which reduces the width of the beam, and the glass slab under investigation. The rays then fall on a combination of two right-angled prisms placed with the reflecting faces close together, but separated by a thin film of air, which arrangement gives rise to a set of interference fringes. From the double prism the light passes through an analyser and is viewed through a telescope. Specimens could be dealt with up to 30 cm. diam. The interference fringes were utilised in determining the amount of strain along the path of the light. Some slabs showed a minimum strain near the centre, but the strain increased rapidly along lines from the centre to the edge. Other slabs, which had been slowly cooled, showed a zone of considerable area practically free from strain, but beyond this the strain increased sharply to the edge. For diagrams and photograph of the apparatus, with method of use, see original paper. A table is given showing the effect of various cooling processes on the amount of strain produced. In the *discussion*, in reply to **Ebert**, the **Author** said the apparatus might be used to investigate the effect of strain produced mechanically. A. W.

389. *Interference Phenomena in Glass Wedges.* **E. von der Pahlen.** (Ann. d. Physik, 39. 6. pp. 1567–1589, Dec. 23, 1912.)—When a pencil of parallel or nearly parallel rays falls at an angle of incidence ϕ on to a feebly wedge-shaped plate of glass of angle ε and mean thickness D, with the plane of incidence normal to the thin edge, then interference fringes are produced, both by reflected and by transmitted light, at a distance E from the centre of the surface, where $E = D \sin\phi \cos^2\phi/(\varepsilon n^2 - \varepsilon \sin^2\phi)$. These fringes are parallel to the thin edge, and lie in a plane containing the thin edge and forming with the surface of the plate an angle α given by the relation $\tan\alpha = \sin\phi \cos^3\phi/(n^2 - 1 + \cos^4\phi)$. When the incident light is directed towards the thin edge, this plane is, in the case of reflected light, on the same side as the source, and the fringes are real, both in reflected and in transmitted light. When the light passes in the reverse direction as regards the edge, both planes lie on the side of the plate opposite the interfering rays, and the fringes are vertical. Their apparent distances apart, projected on a plane normal to the line of vision, are $= \lambda \cos\phi/2\varepsilon(n^2 - \sin^2\phi)^{\frac{1}{2}}$. There are other fringes at distances from the above $= \lambda \sin\alpha p/2\varepsilon^2 \sin\phi \cos(\phi - \alpha)$, where p has the successive values $\pm 0, \frac{1}{2}, 1, 1\frac{1}{2}, 2$, etc. The planes and mutual distances are the same as before. E. E. F.

390. *Scattering of Light.* **F. Herxheimer.** (Phys. Zeitschr. 13. pp. 1106–1112, Nov. 15, 1912.)—This paper deals with a method of measuring the intensity of the light scattered in various directions around the primary beam. The method has been tested with sal-ammoniac clouds. The absorption is found to reach a maximum about 15 minutes after the formation of the cloud, when a certain size of particles is reached apparently. J. M.

391. *Light Propagation in Layered Media.* **A. Garbasso.** (Ann. d. Physik. 39. 6. pp. 1073–1107, Dec. 23, 1912.)—The first part of this paper is

theoretical of a general kind, and treats the subject by aid of Lagrange's generalised co-ordinates. The second part deals with the natural phenomena of mirage in its various forms, especially the Vince mirage (one inverted image between two erect ones) and those observed by Monge and by Parnell (two inverted images between three erect ones). Experimental work has also been carried out with gelatines through which are diffused electrolytes.

E. H. B.

392. *Emission from Tungsten and Carbon at Glowing Temperatures.* **A. G. Worthing.** (Astrophys. Journ. 36. pp. 345–360, Dec., 1912.)—A paper describing experiments which show how the emission from tungsten and carbon deviates from Lambert's cosine law at glowing temperatures. The brightness variation as a function of the angle of emission was measured for carbon at one temperature and for tungsten at two, using light of wave-length 0·63 μ; also for tungsten and carbon at one temperature each, using light of wave-length 0·46 μ. It was found that the brightness of tungsten, beginning with normal emission, increases with the angle of emission, reaches a maximum at about 75°, and for somewhat larger angles decreases rapidly. The brightness of carbon, beginning with normal emission, decreases with increasing angle of emission, the rate of decrease increasing with the angle. The relative brightness variations for light of short wave-length 0·46 μ for tungsten are noticeably less than those for the light of longer wave-length 0·63 μ. The same effect was found with carbon, but the difference is not so great. The relative brightness variations for tungsten at the higher of the two temperatures chosen are about 20 or 25 % greater than the corresponding variations for the lower temperature. No definite change with temperature was found for carbon. The average brightness of a tungsten cylindrical filament, viewed normally to its axis from a distance, is found to be about 3 % greater than the brightness of the central part, that for a carbon filament about 5 % less.

A. W.

393. *Determination of Spectrum Luminosity Curves by the Method of Critical Frequency.* **H. E. Ives.** (Phil. Mag. 24. pp. 352–370, Sept., 1912. Electrician, 71. p. 59, Oct. 18, 1912. Abstract.)—This paper is supplementary to a previous one [see Abstract No. 1246 B (1912)] in which the existence of a reversed Purkinje-effect with the flicker photometer was noted at low illuminations. The effect is now investigated by the "critical frequency" method, *i.e.* observing the speed at which the flicker-effect of a rotating disc just vanishes. The method leads to a similar conclusion. The reversal takes place about 0·25 candle-metre, where a profound change in the nature of vision seems to occur. The results are affected by the area of the retina on which the luminous image is received; at low illuminations the fovea is most sensitive to flicker with red light, the peripheral retina to flicker with the blue light. These experiments confirm the impression that the cones on the retina are chiefly active in the case of intermittent and alternating stimuli. **Rayleigh.** (Phil. Mag. 24. pp. 301–302, Aug., 1912.)—Rayleigh comments on the recent remarks of H. E. Ives [see Abstract No. 1246 B(1912)] that no satisfactory theory of the action of the flicker photometer exists. But it is suggested that the sensation of flicker is due to the alteration in the iris of the eye, when exposed to a fluctuating light. Further confirmation of the suggestion might be made by studying experimentally these variations and ascertaining whether the flicker match coincides with quiescence of the iris.

J. S. D.

394. *Point Sources of Light.* **C. C. Paterson** and **B. P. Dudding**. (Phys. Soc., Proc. 24. pp. 379–397; Discussion, pp. 398–399, Oct., 1912.)—A paper dealing with the visibility of point sources of light, and describing measurements of the same. A point source is taken as one whose linear dimensions subtend at the eye an angle less than the eye's resolving power, *i.e.* about 30″ for a mean wave-length $0{\cdot}5 + 10^{-3}$ mm. and pupilar aperture 4·5 mm. The experiments showed that the visibility of a point source of light is independent of its intrinsic brightness and is proportional to its total candle-power; also that the visibility of a given source varies inversely as the square of its distance from the eye of the observer. The author's results for visibility of distant sources agree fairly closely with those calculated from the report of the Deutsche Seewarte of 1894. In the following table columns A and B give the candle-power (British) of white light required in clear air for visibility at the different ranges shown, A referring to the report of the Deutsche Seewarte, B to the authors' results.

Range.	A.	B.
1 sea-mile = 1855 m. approx.....	0·47	0·41
2 sea-miles.....	1·9 (0)	1·6 (0)
5 sea-miles.....	11· (8)	10· (0)

Experiments on the change of visibility of a point source when viewed through spectacle lenses showed that for distances greater than 3 m. positive lenses produced a marked loss of visibility amounting to 60 % in the case of a 1-dioptrie lens. Negative lenses for the same distances produced much less dimming; in the case of a green point source a 1-dioptrie (negative) lens produces a brightening of 20 %. Experiments on the effect of spherical aberration showed a somewhat improved definition of the image of the point when viewed through a smaller stop, but this had very little effect in lessening the relative loss of visibility of the green light when viewed through a positive lens. Further experiments were made in which the relative dimming of green and red point-sources was investigated. The results show how greatly the green light is dimmed, relatively to the red light, when viewed through any positive lens, and indicate that this is due mainly to the chromatic aberration of the eye. A. W.

395. *Image Errors of Optical Systems.* **E. Waetzmann.** (Ann. d. Physik, 39. 5. pp. 1042–1052, Dec. 5, 1912.)—Describes an interference method of investigating image errors of lenses or lens systems. The interference fringes used are those dealt with by Mascart and by Lummer, who gave the theory [Wied. Ann. 23. p. 513, 1884]. A plane-parallel glass plate, ABC, is placed at an angle of 45° with the principal axis of a lens L and with the middle point B on that axis. A plane mirror M is placed on the other side of the lens at its principal focus, and perpendicular to the principal axis. A narrow beam of parallel light incident at 45° on some point of the lower half AB of the glass plate gives by external and internal reflection two rays which pass through the lower half of the lens, are reflected from the mirror M, pass then through the upper half of the lens on to the upper half BC of the glass plate, and after external and internal reflection respectively are parallel to their original direction, and have no path difference. If a broad beam of parallel light falls on ABC the field is uniformly bright. But if the mirror M is turned slightly

from the null position the reflected rays fall at a different angle on the plate ABC, and the two rays above considered will have a path difference; so when a broad beam falls on ABC a system of interference curves are formed. Using a similar arrangement it is shown how the errors of lens systems having chromatic or spherical aberration may be investigated. Photographs are reproduced of typical cases. [See also Abstract No. 1690 (1911).] A. W.

396. *Resolving Power of the Photographic Plate.* **E. Goldberg.** (Photographic Journ. 52. pp. 300–316; Discussion, pp. 316–319, Nov., 1912.)—After a brief introduction, the subject is dealt with under the following headings:—Sharpness of reproduction and sharpness factor; determination of sharpness factor; turbidity curves and turbidity factor; relation between the sharpness curve and turbidity factor; limits of resolution. In the experiments a simple method, in which the lens is dispensed with, is employed. The principal practical conclusions arrived at are:—In all cases where, with a common or bad lenses the greatest possible sharpness is required, it is necessary to take care that a negative of the steepest possible gradation is obtained. For this purpose a "hard-working" emulsion must be used and full development given. The same rule also holds where the lens is of the best quality but the image is affected by the use of a filter or prism. In all these cases want of sharpness due to the resolving power of the plate is of small importance compared to the want of sharpness caused by the optical equipment, because it is far surpassed by the latter. An investigation of this point is being undertaken by the author. If a first-class lens is used to photograph and only the middle of the picture is required, where the aberrations of the rays are relatively small, then results differ as follows:—When fine structures, *e.g.* narrow neighbouring lines or points, fine drawings, reduced maps, etc., are photographed, where all light places of the picture possess the same intensity of light, there is no need to pay attention to the turbidity factor. With very short exposures the influence of the spreading of a single line or point (turbidity factor) has no value. On the other hand, the resolving limit of the plate in question in these cases plays an important part. Particular difficulty is offered by the exposures where fine lines or points of differing light intensity must be reproduced close together. Such cases are continually encountered with star and spectrum photography. Here, lines or points, the light-intensity of which is extraordinarily different (*e.g.* 1 : 1,000,000), lie closely together, so that the influence of the turbidity factor surpasses by far all other factors if a good lens is used. Short exposures are impossible, as the points of small light intensity cannot then be rendered, but with sufficiently long exposure the spreading of the disc is already so strong that the weakly lighted points merge into the image of the discs caused by the points of strong light-intensity and therefore cannot now be perceived. On that account plates must be used which have the smallest possible turbidity factor with regard to their resolving limit. At present, process and lantern plates unite a proportionately small degree of turbidity with a good resolving limit. It is, however, not impossible so to improve highly sensitive plates as regards the qualities discussed, that a good resolution can be attained both with short and long exposures.

A. E. G.

397. *Action of Ink on the Photographic Plate.* **G. de Fontenay.** (Comptes Rendus, 155. pp. 1610–1612, Dec. 30, 1912.)—Written or printed matter when placed for some time in contact with the sensitised surface of a photographic plate affects the latter in such a manner that, after developing, a positive or

negative reduction is obtained. It is found that the precise nature of this phenomenon depends to a large extent upon the time of contact and the temperature, as also upon the nature of the ink and the paper surface. When all sources of error are eliminated it does not appear probable that any effect is attained which can be attributed to a purely chemical reaction, and there is no evidence that the results are produced by any new or particular radiation. A. E. G.

398. *Optical Behaviour of Centrifugalised Gold Hydrosols.* **H. Robitschek.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1197–1212, July, 1912.)—For the purpose of finding if there is any connection between size of particle and colour, the author subjected solutions of gold hydrosols (some prepared by chemical reduction, some by the Bredig method) to centrifugalisation. It was found that the upper layer in all cases thereby became relatively more transparent for red than for blue light, whereas the lower layer is more transparent for blue than for red light, and appears to the eye alone of a dark blue colour. It appears, therefore, that the small particles of colloidal gold are more transparent for red light than for blue, whereas the larger particles are more transparent for blue. [Compare Abstract No. 242 (1912).] A. F.

399. *Molecular Symmetry.* **A. Cotton.** (Comptes Rendus, 155. pp. 1232–1234, Dec. 9, 1912.)—Using the same notation as in the case of the corresponding crystal, if E_m be the ellipsoid representing the magnetic properties of the molecule, E_e the electrical, E_o the optical, and θ_o the angle between the greatest axes of E_m and E_e; then if magnetic and electric fields at an angle θ are applied simultaneously double refraction will be greatest when θ passes through θ_o. Thus θ_o is found. A study of the optical properties would therefore furnish a basis of classification of molecules according to the angles which the greatest axes of E_m and E_e make with the three axes of E_o, or in the case of the uniaxals, according to the form of the ellipsoid of revolution. The only ambiguity would be in the case of the biaxals (where θ_o would be 0), which might be confounded with the uniaxals. J. M.

400. *A Registering Micro-photometer.* **P. P. Koch.** (Ann. d. Physik, 39. 4. pp. 705–751, Nov. 12, 1912.)—A complete account of the method of using the new apparatus is given and a description in detail of the various parts. There is also a series of results in tabular form and reproductions from photographs. The blackening curves obtained with the Hartmann and the registering micro-photometers are compared. A. E. G.

401. *Design of Spectrograph Objectives.* **K. Schwarzschild.** (Preuss. Akad. Wiss. Berlin, Ber. 53. pp. 1220–1239, 1912.)—A short discussion is given of the conditions to be fulfilled in the design of objective lenses for spectrographs, in order to obtain the requisite definition over an extended field and throughout a given length of spectrum. Special reference is made to the performance of an objective for spectrograph III of the Potsdam Astrophysical Observatory. C. P. B.

402. *Theory of Moving Mirror.* **A. Harnack.** (Ann. d. Physik, 39. 5. pp. 1053–1058, Dec. 5, 1912.)—A mathematical treatment which obtains results in agreement with those derived by A. Einstein (in 1905) on the relativity principle. E. H. B.

403. *Emission and Absorption of Stratified Bodies.* **W. Voigt.** (Ann. d. Physik, 39. 6. pp. 1381–1407, Dec. 23, 1912.)—An analytical paper in which are

obtained general formulæ for the emissions in all directions of an isotropic body arranged in parallel layers which change steadily and so slowly in density that internal reflections may be neglected though the corresponding absorptions are taken into account. [See Abstract No. 197 (1913).] E. H. B.

404. *Emission and Diffuse Reflection.* **F. Jentzsch.** (Ann. d. Physik, 39. 5. pp. 997–1041, Dec. 5, 1912. Extract from the Giessener Habilitationsschrift.) —A general discussion and mathematical treatment. Does not admit of brief abstract. A. W.

405. *Lummer Interference Plate.* **F. Koláček.** (Ann. d. Physik, 39. 6. pp. 1431-1490, Dec. 23, 1912.)—A detailed mathematical theory of the phenomena presented when working with a Lummer-Gehrcke interference spectroscope. E. H. B.

406. *Polarisation of Light due to passage through a Slit.* **P. Zeeman.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 599–601, Nov. 28, 1912.) —In a previous communication the author drew attention to the fact that by the polarising action of the grating the ratio of the observed intensities of the components of a triplet differs considerably from the ratio present in the light as it is emitted by the source [Ibid. Oct. 26, 1907]. Besides the action of the grating the polarising action of the slit affects the intensity ratio. Experiments are described which show that the vibrations perpendicular to a very narrow slit hardly traverse the slit ; the ratio of intensities of the components of a triplet under observation gradually changes as the slit is narrowed. Hence errors may be introduced in observations. When the resolution of lines originally diffuse toward one side of the spectrum is investigated, apparent shifts and dissymmetrical separations may result. A quartz plate introduced before the slit of the spectroscope and giving a rotation of the plane of polarisation of 45°, eliminates at the same time both errors due to the polarising action of the grating and those caused by narrowness of the slit. A. W.

407. *Experiment on Polarised Light.* **F. P. Liesegang.** (Phys. Zeitschr. 13. pp. 1055–1056, Nov. 1, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—Describes with six figures the rotation of the plane of polarisation and its detection after repeated reflection at mirrors or piles of plates. E. H. B.

408. *Iron Spectrum for Wave-length References.* **L. Glaser.** (Zeitschr. wiss. Phot. 11. pp. 375–380, Dec., 1912.)—By an agreement among the members of the International Union for Co-operation in Solar Research the spectrum of iron was chosen as furnishing a series of International standards of wave-length, to be used as a scale for future spectrum references ; some of the gaps in the iron spectrum were to be filled up by nickel lines. The author describes his work in photographing the spectrum of samples of nickel-steel of different composition, with references to plates of the spectra obtained. C. P. B

409. *Ultra-violet Magnetic Rotation in Gases.* **J. F. Sirks.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 773–788, Dec. 30, 1912.)—A modification of the apparatus previously used by Siertsema for investigating magnetic rotation in gases was made, so that Landau's half-shadow method of investigation could be employed. Also quartz was substituted for glass so that measurements could be made with ultra-violet light. The gases dealt

with were oxygen, hydrogen, and CO_2. Taking the rotatory constant for the mercury line λ5780 to be unity, and combining the author's results with those previously obtained by Siertsema, the following table is obtained for the relative rotations for lines of various wave-lengths.

λ.	R/R_{5780}.		
	Oxygen.	CO_2.	Hydrogen.
5780	1·00	1·00	1·00
5460	1·08	1·12 (5)	1·12 (5)
4860	1·26 (5)	1·43 (5)	1·44
4360	1·50	1·80 (5)	1·81 (5)
4045	1·65 (5)	2·10	2·15
3665	1·96 (5)	2·57	2·64
3130	2·69 (5)	3·76	3·90
2805	3·36 (5)	4·77 (5)	5·14
2655	3·75 (5)	5·49	5·97 (5)
2535	—	6·19 (5)	6·67
2480	—	—	7·09
2400	—	—	7·76
2380	—	—	7·94

The oxygen curve deviates considerably from those for the other gases. On the assumption that ultra-violet refraction in hydrogen satisfies a formula of the type $n^2 = A + B/(\lambda^2 - \lambda_m^2)$, in which λ_m, the wave-length of the ultra-violet free vibration is taken to be 0·087 μ, the following values have been calculated for e/m :—

λ in $\mu\mu$	589	405	313	265	248	238
$e/m \times 10^{-7}$...	1·77	1·78	1·81	1·85 (5)	1·86	1·87 (5)

The increase here found for e/m does not accord with the assumption of a single ultra-violet free vibration. A. W.

410. *Wave-lengths of Neon.* **I. G. Priest.** (Bureau of Standards, Bull. 8. pp. 539–544, Nov. 1, 1912.)—The 10 wave-lengths of neon given in this paper have been determined by the method of reflection fringes previously described [see Abstract No. 334 (1911)]. The lamps used were of the high-voltage "vacuum tube" type and were operated on a transformer circuit. The probable errors given are all less than 1 part in 10^7. The reference standard is the wave-length of Cd red, taken as 6438·4696 I.Å. units. The value 5852·4862 I.Å. units for the bright yellow neon line is derived from the author's previous determination relative to Cd red by reducing to the present definition of the I.Å. unit. Errors of method and accuracy of results are discussed. The values found for the neon lines are as follows : 5852·4862, 5881·8958, 5944·8344, 6074·3383, 6096·1608, 6143·0600, 6266·4948, 6304·7929, 6382·9882, 6402·2392. A. W.

411. *Ultra-violet Band of Water Vapour* (λ = 3064). **L. Grebe** and **O. Holtz.** (Ann. d. Physik, 39. 6. pp. 1243–1250, Dec. 23, 1912.)—Discusses the origin and structure of the ultra-violet water-vapour band extending from λ = 3063·547 to λ = 3291·687. A table is given of the wave-lengths in international units of the lines of the band, and some of these are arranged in a series which approximately satisfies Deslandres' law. A. W.

412. *Spectroscopic Investigation of Ionium.* **F. Exner** and **E. Haschek.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1075–1077, June, 1912.)—From about 10,000 kg. of pitchblende residues about 130 gm. of material had been separated by A. v. Welsbach. Chemically it was principally thorium oxide, with a small proportion of the rare earths Y, Sc, and Ce. Meyer and v. Schweidler had investigated the radio-active properties of the material, and found an α-radiation of approximately 10,000 times that of pure Th. Assuming the transformation period of ionium to be only equal to that of Ra, the activity found would correspond to an ionium-content in the material of 2·5 per 1000. But from the results obtained by various workers it would appear that the transformation period of ionium is about 50 times that of Ra, which value would give an ionium-content of at any rate 10 %. If this were the case it would be natural to expect, if ionium is of an elementary nature, a characteristic ionium spectrum to be given. The authors' investigation of the arc spectrum of the material, using a large Rowland grating, showed, however, not a single line which did not belong to known elements of the group of rare earths. Besides the complete Th spectrum, the spectra of Ce and Sc were prominent, that of Y being also fairly strong. Traces of aldebaranium, cassiopeium, thulium, neoholmium, and europium were also found. It seems probable that the ionium-content of the material was in error, but it seems unlikely that the estimate of the transformation period is so much in error as would be required to explain the results obtained. The authors have also investigated a strongly active preparation of mesothorium and metallic radiolead, without finding any hitherto unknown lines. In radiolead a considerable thallium-content was found. A. W.

413. *Investigation of Spectrum of Ionium.* **A. S. Russell** and **R. Rossi.** (Roy. Soc., Proc. Ser. A. 87. pp. 478–484, Dec. 13, 1912.)—The arc spectrum of a highly active preparation of ionium containing thorium has been investigated. No new lines due to ionium have been obtained. From this result it has been deduced that the period of ionium cannot exceed 12,000 years. This result, taken in conjunction with Soddy's results on the period of ionium, points to the existence of at least one new comparatively long-lived body between uranium and ionium in the disintegration series. [See Abstract No. 958 (1911) and preceding Abstract.] A. W.

414. *Absorption Spectrum of Tellurium Vapour.* **E. J. Evans.** (Astrophys. Journ. 36. pp. 228–238, Oct., 1912.)—A continuation of previous work by the author and Antonoff [Abstract No. 43 (1912)] on the absorption spectrum of Te-vapour. The experimental arrangement was similar to that previously used. It was found that the bands in the absorption spectrum of Te extend from λ3900 to about λ6000. In addition to a band spectrum the vapour gives a general selective absorption. The absorption spectrum of Te is similar to that of Se, but compared with the spectrum of the latter it is displaced toward the red. For small pressures absorption bands are first photographed in the extreme violet (λ3900), and as the pressure increases, absorption bands are also photographed in regions of greater wave-length. At pressures sufficient to show the presence of bands in the region λ5300–λ6000, there is complete absorption in the violet and blue. When the pressure of the vapour is low, the absorption bands in the region λ3900–λ4500 diminish in intensity with increase of temperature until they almost disappear at 1200° C. This result may be explained on the hypothesis that the absorption bands are due to complex molecules, which are present in Te-vapour at low temperatures.

These molecules are completely dissociated at high temperatures, and hence the absorption bands are not visible. The absorption spectra of a constant mass (0·002 gm.) of Te-vapour at 1000° and 1350° C. do not show any difference. Both spectra show the presence of bands between λ5300 and λ6000, and a continuous absorption from λ5300 to λ3500. The intensities of the bands are not affected by a change of temperature from 1000° to 1350° C. From the experimental results it is impossible to determine whether these bands are due to diatomic molecules or more complex ones. A. W.

415. *Absorption Spectra of some Uranyl Salts.* **A. Mazzucchelli** and **O. G. d'Alceo.** (Accad. Lincei, Atti, 21. pp. 850–854, Dec. 15, 1912.)—Reproductions are given of the absorption spectra of sodium uranyl oxalate with and without the addition of pyridine or hexamethylene-tetramine, and of sodium uranyl tartrate alone and in presence of pyridine, showing that the addition of the amine slightly alters the spectra of the uranyl salts, thus indicating chemical reaction between them. W. H. Si.

416. *Band Spectra of Aluminium, Cadmium, Zinc.* **E. E. Howson.** (Astrophys. Journ. 36. pp. 286–292, Nov., 1912.)—Band spectra were produced by the method described by Barnes [Abstract No. 1681 (1911)], and photographed with a Rowland concave grating of 14 ft. radius of curvature, using a comparison spectrum of iron. Tables are given of the component lines of the bands found, with suggested arrangement into series represented by the formula published by Fowler for magnesium, $\lambda m = a + bm + cm^2$.

C. P. B.

417. *Spectra of Low-potential Discharges in Air and Hydrogen.* **G. S. Fulcher.** (Phys. Zeitschr. 13. pp. 1137–1142, Dec. 1, 1912.)—The author has previously investigated the light emitted by nitrogen, hydrogen, and oxygen molecules when bombarded by kathode rays with velocities corresponding to p.d.'s of from 500 to 5000 volts [see Abstract No. 372 (1912)]. The present paper describes a continuation of the work for low potentials. A Wehnelt kathode was used in a special apparatus, and the anode was perforated so that by applying a field a bundle of kathode rays of determinate velocity could be sent through the small hole into the chamber behind the anode, which was supplied with the gas under investigation. With the electrodes about 5 mm. apart and a sufficiently hot kathode, the minimum p.d.'s required were found to be: For hydrogen, 20 volts; for air, 27 volts; for oxygen, 45 volts; the pressure of the gas in the apparatus being of the order of 0·1 mm. of Hg. Tables are given of the principal band lines of hydrogen and of the intensity ratio of the lines in the hydrogen spectrum for high and low discharge potentials; photographs of the spectra of air and of hydrogen for different low potentials are also reproduced. The variations of the spectrum were similar in air and hydrogen, and it is concluded that the variations are due to the variations in the energy of the kathode rays; that the light is the result of the ionisation by the rays; and that the slow kathode rays ionising nitrogen give rise to both the positive and negative band spectra, whose intensity ratio depends on the energy of the ionising rays. It was also found that the light going from the space between the electrodes into the discharge chamber showed similar variations to those of the spectrum produced by the kathode rays, so that the light in the discharge chamber for these low potentials is principally due to ionisation by the kathode rays. The slowest rays (30 volts) give rise only to the positive nitrogen band

spectrum, but the relative intensity of the negative bands increases very rapidly with the energy of the exciting beam, so that for 50 volts it is the stronger, and for higher potentials it greatly exceeds the positive band spectrum in intensity. In oxygen the spectrum for a discharge potential of 75 volts consists principally of the negative bands in the red and yellow, but the spark and series lines are also present. Reducing the potential to 45 volts caused the negative band to disappear. A. W.

418. *Band Spectrum of Mercury.* **E. Liese.** (Zeitschr. wiss. Phot. 11. pp. 349–374, Dec., 1912.)—Using a quartz mercury lamp of the Heraeus type and the current from a transformer, which could give $\frac{3}{4}$ amp. at 2000 volts, the band spectrum of mercury was obtained and photographed. The wave-lengths of the lines were determined by comparison with normal iron lines and are tabulated. The lines are arranged in a number of series, which approximately follow Deslandres' laws. A. W.

419. *Zeeman-effect.* **F. Paschen** and **E. Back.** (Ann. d. Physik, 39. 5. pp. 897–932, Dec. 5, 1912.)—This paper deals with the following theory put forward to explain the deviation of some series lines from Preston's law: The vibrations corresponding to simple lines, whose magnetic separations are all normal, are stable; those causing doublets or triplets, etc., are unstable and forced. The smaller the difference in frequency the greater the instability. The cause of the emission of the particular arrangement of lines is at the same time the cause of their abnormal magnetic separation. A strong magnetic field may, in the case of close lines, upset the equilibrium and change the type in a single line with the resulting normal separation, which has been observed by the author in the case of the oxygen triplet 3947·438, 3947·626, 3947·731, and in the spectra of other elements. Thus the normal triplet may come from a single line or a very close doublet or triplet, and appear where a complex magnetic type would be expected. The atomic internal forces work against the formation of groups of lines, so instead of a close doublet or triplet member of a series we may find a single line, *e.g.* the lithium lines perhaps. J. M.

420. *Zeeman-effect of Hydrogen Lines.* **F. Croze.** (Comptes Rendus, 155. pp. 1607–1610, Dec. 30, 1912.)—According to F. Paschen and E. Back [see preceding Abstract] H_α, H_β, and H_γ do not give normal triplets, and the polarisation of the middle component in each case is incomplete. The author finds, on repeating his experiments [see Abstract No. 1367 (1912)], the same result as before, *i.e.* normal triplets for all three lines, and in addition for H . J. M.

421. *Magnetic Spectrum of Bromine.* **G. Ribaud.** (Comptes Rendus, 155. pp. 900–903, Nov. 4, 1912.)—The author has obtained the following results:—The Zeeman-effect, if it exists, is under $\frac{1}{20}$ Å. in a field of 24,000 gauss. All the absorption lines of bromine show rotatory magnetic polarisation when the vapour is under suitable pressure, but the spectrum changes completely with change of pressure. To study the phenomenon in a monochromatic light, a much finer line than the green line from the mercury arc would be required, as within this width many absorption lines of bromine are contained. The transversal effect observed by Cotton for nitrous vapours is absent, at all events in a field of 28,000 gauss. J. M.

422. *D-Lines Emitted by Sodium Salts.* **K. Iwanow.** (Phys. Zeitschr. 13. pp. 1112–1118, Nov. 15, 1912.)—The author has obtained, by the photographic-photometric method, the intensity curves for the emission lines D_1 and D_2 obtained from NaI, NaBr, NaCl, $NaCO_3$, and $NaNO_3$. He finds that the more stable compounds emit less light, but that as the temperature of the flame increases, the differences in the curves decrease. Making the flame more homogeneous by substituting a Méker for a Bunsen burner does not appreciably affect the dip in the centre of the curves corresponding to the reversal of the lines. The conclusions drawn are: (1) That temperature is the chief factor determining the emission of the D lines; (2) that the lines are emitted chiefly by neutral atoms, not by ions (from the fact that the lines are much the same from different salts, although the electrical conductivity varies); (3) that the inhomogeneity as regards emission and absorption at the outer edge of the flame accounts for the reversal of the lines. J. M.

423. *Zeeman-effect.* **R. Fortrat.** (Comptes Rendus, 155. pp. 1237–1239, Dec. 9, 1912.)—The author has measured the magnetic separation of the blue and of the ultra-violet zinc lines, which belong to the same series—

$$4680, 4722, 4810 \text{ give } \delta\lambda/\lambda^2 H = 1{\cdot}8712 \times 10^{-4};$$
$$3036, 3018 \text{ give } \delta\lambda/\lambda^2 H = 1{\cdot}872 \times 10^{-4},$$

furnishing a verification of Preston's law. J. M.

424. *Structure of Mercury Lines.* **H. Nagaoka** and **T. Takamine.** (Phys. Soc., Proc. 25. pp. 1–29; Discussion, pp. 29–30, Dec., 1912.)—Describes an elaborate investigation of the structure of different mercury lines, using an echelon spectroscope crossed by a Lummer-Gehrcke plate. The authors find that the 5790 line consists of 8, the 5769 line of 4, the 5461 of 9, the 4359 of 11, the 4078 of 6, and the 4047 of 7 components, whose positions in general agree with those found by recent observers. A simple relation is indicated between the distances of the components from the principal line in each case, and a further relation between the quotient of each of these distances by the wave-length of the principal line is given, which holds for all the lines. The relative intensities of the component lines were determined by interposing an echelon photograph between a constant source of light and a linear thermopile, and noting the changes in the deflection of a galvanometer in series with the pile as the plate was moved across the face of the pile. In every case there appears to be a simple relation between the position and intensity of each component line. In the *discussion* **C. H. Lees** and **Stansfield** pointed out that ambiguity as to the order of echelon spectrum lines could easily be avoided by employing a prism to increase or decrease slightly the echelon dispersion. The latter also, among other things, called attention to the Fabry and Perot bands superposed on the ordinary spectrum due to the light reflected backwards and forwards between the plates. [See also Abstracts Nos. 1395 (1906) and 494 (1912).] A. W.

425. *A New Measurement of the Optical Parameters of the Sodium Line D_1.* **K. Iwanow.** (Phys. Zeitschr. 13. pp. 1119–1123, Nov. 15, 1912.)—Q', which is proportional to the number of dispersion-electrons per unit volume, is measured by the magnetic rotation of the plane of polarisation outside the Zeeman doublets. ν', the damping constant of the electron motion, is determined from the intensity curve (obtained by the photographic-photometric method) for one component of the Zeeman doublets of the absorption line D_1.

According to H. A. Lorentz $v' \propto$ vapour density $\times \sqrt{}$(absolute temperature). The author finds that $v' \propto \sqrt[3]{}$(vapour density) approx., and concludes if the damping is only a force of the nature of friction, then all the sodium atoms do not take part in absorption and emission. The fraction active, he finds, decreases as more sodium salt is added to the flame. The max. absorption coefficient $= 2{\cdot}4 \times 10^{-4}$. J. M.

426. *Zeeman-effect.* **G. J. Elias.** (Archives Musée Teyler, 1. Ser. 3. pp. 25–28, 1912.)—The author has made a study of the variation in the polarisation and intensity of the components of the emission lines chromium 520·620 and copper 510·575, when the angle between the magnetic field and the direction of the light is varied. J. M.

427. *Convergence Frequency in Spectral Series.* **F. Sanford.** (Astrophys. Journ. 36. pp. 255–262, Oct., 1912.)—The object of this paper is to show some relations between the convergence frequencies (A, in Kayser and Runge's formula) in the spectral series of certain atoms and some of their other physical properties. A. W.

428. *Influence of Temperature on the Phosphorescence of Alkaline-earth Sulphides.* **H. E. Ives** and **M. Luckiesh.** (Astrophys. Journ. 36. pp. 330–343, Nov., 1912.)—Experiments with the sulphides of Zn, BaBiK (Balmain's paint), and SrZnFl show that the decay of phosphorescence in these substances is represented by Becquerel's formula $I^{-x} = a + bt$, where x is a function of the temperature, independent of the quantitative composition of the phosphore, and a and b are functions of the composition and heat-treatment of the sulphide. The flashing-up under the influence of infra-red vibrations is greatest at low temperatures, rapidly declining with rise of temperature. For ZnS the effects of infra-red rays and heat during excitation and the early stages of decay are opposite, that of the infra-red rays being upon the permanent process only. It is suggested that the phenomena may be explained by taking into account the complex character of the phosphores, and ascribing to each component its own temperature-scale, the early part of the decay being given chiefly by the high-temperature components, the later part by the low. [See also Abstract No. 161 (1912).] W. H. Si.

429. *Excitation of Phosphorescent Alkaline Earths by Canal Rays.* **H. Baerwald.** (Ann. d. Physik, 39. 4. pp. 849–886, Nov. 12, 1912.)—The effects obtained by previous observers are dealt with at some length. A complete account of the present experimental arrangements and methods of making observations is also given. As a result it is found that in the excitation of the phosphorescent alkaline earths by canal rays the charged particles play a much more important part than the uncharged. The nature of the charge, however, does not appear to make any difference, the action with positive or negative being of relatively the same degree. A distinction is also obtained between the excitation of phosphorescence and the chemical action of the canal rays on the light-sensitive layer, by which only the number of particles and not their charged condition comes in question. The emission of phosphorescence appears to be essentially an electrical phenomenon. A. E. G.

430. *Intensity of α-Radiation from Uranium.* **S. Meyer** and **F. Paneth.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1403–1412, July, 1912. Communication

from the Inst. f. Radiumforschung.)—The authors have made ionisation measurements with thin films of U_3O_8 and Ra with the object of determining the relative ionisation produced by the Ur and Ra in the mineral. The results obtained for the ratio (ionisation Ur)/(ionisation Ra) is 100/57·3 under conditions in which all the α-radiation to one side is utilised. This value agrees with McCoy's value [Abstract No. 421 (1907)] but not with Boltwood's which is 100/45 [Abstract No. 154 (1909)]. The theoretical value deduced from the ranges of UrI, UrII, and Ra is calculated to be 100/58, and the agreement with the observed value precludes the possibility of the presence of a third α-radiating substance in ordinary uranium, and also affords additional proof that UrY is only a side product. E. M.

431. *γ-Rays Excited by the β-Rays of Radium.* **J. Chadwick.** (Phil. Mag. 24. pp. 594–600, Oct., 1912.)—It has been shown by Gray [Abstract No. 1709 (1912)] that when the β-rays of RaE impinge on any material they excite γ-rays. In the present paper this result has been extended to the β-rays from RaEm in equilibrium. A quantity of RaEm contained in a thin glass tube was placed in a strong converging magnetic field produced by using suitably shaped pole-pieces of an electromagnet. The β-rays were thus concentrated on a metal sheet and any excited γ-radiation could be measured in an ionisation chamber where the leak was balanced on a principle similar to that of Rutherford and Chadwick [Abstract No. 1201 (1912)]. In the experiments the primary γ-rays were cut down to less than 5 % by a slab of lead. Excited γ-rays were found for all the materials examined, the relative amounts varying from 75 for a thick sheet of Al to 100 for uranium. The amount was, however, only 0·3 % of the primary γ-radiation from the source even after correcting for the fact that only a fraction of the β-particles fall on the radiator. Measurements of the absorption coefficient of the excited γ-radiation showed it to be more penetrating with increase of atomic weight of radiator, although even for lead its absorption coefficient was about three times that for the primary γ-radiation of the source. If it be supposed that the γ-rays from radio-active matter are produced by the β-rays, the experiments bring out clearly the high efficiency of the transformation of β-rays into γ-rays during the disintegration of the atom of RaC, compared with the efficiency of the conversion of β-rays into γ-rays when the former fall on matter of high atomic weight. As Gray has shown, the exact converse holds for the product RaE. E. M.

432. *Ranges of α-Particles from Thorium and Actinium Products.* **H. Geiger** and **J. M. Nuttall.** (Phil. Mag. 24. pp. 647–654, Oct., 1912.)—In the present investigation the authors have continued their work on the determination of the ranges of the α-particles from different radio-active products [Abstracts Nos. 163, 861 (1912)]. For the Th and Ac families the estimations are difficult owing to the short periods of some of the products and the consequent impossibility of separating them. Thus AcEm and AcA are always associated with AcX. In the method employed two bell-jars are placed opposite each other and separated by a large sheet of thin and uniform mica. The source is placed at the bottom of the lower bell-jar with a grid of cylindrical tubes to canalise the α-particles. The two bell-jars are air-tight, the lower one containing air at adjustable pressure, and the upper one containing hydrogen. By altering the pressure in the lower bell-jar a Bragg ionisation curve is obtained by measurements in a shallow ionisation chamber in the upper bell-jar. In the case of the Th-products a very active thin layer of

ThX was used as a source, a piece of mica being placed directly over it to prevent the escape of ThEm. Thus the ionisation curve obtained is the resultant of the effect of the α-particles from ThX, Em, A, C_1, and C_2. By separate observation of the ionisation curve for the active deposit alone, $(C_1 + C_2)$, the curve is analysed and the ranges are deduced. The following table gives the collected values together with others. Column 4 gives the initial velocities calculated from the formula $v^3 = aR$, where R denotes the range and a is a constant. The results verify the linear relation between the logarithms of the transformation constants and the logarithms of the ranges of α-particles from products of the same radio-active family.

RANGES OF α-PARTICLES.

Substance.	Ranges at 0° C.	Ranges at 15° C.	Initial Velocity.
Uranium 1	2·37 cm.	2·50 cm.	1·47 10^9 $\frac{cm.}{sec.}$
Uranium 2	2·75	2·90	1·54
Ionium	2·85	3·00	1·56
Radium	3·13	3·30	1·61
Ra Emanation	3·94	4·16	1·74
Radium A	4·50	4·75	1·82
Radium C	6·57	6·94	2·06
Radium F	3·58	3·77	1·68
Thorium	2·58	2·72	1·51
Radiothorium	3·67	3·87	1·70
Thorium X	4·08	4·30	1·75
Th Emanation	4·74	5·00	1·85
Thorium A	5·40	5·70	1·93
Thorium C_1	4·55	4·80	1·82
Thorium C_2	8·16	8·60	2·21
Radioactinium	4·36	4·60	1·80
Actinium X	4·17	4·40	1·77
Act Emanation	5·40	5·70	1·93
Actinium A	6·16	6·50	2·02
Actinium C	5·12	5·40	1·89

E. M.

433. *Origin of β- and γ-Rays from Radio-active Substances.* **E. Rutherford.** (Phil. Mag. 24. pp. 453–462, Oct., and pp. 893–894, Dec., 1912. Le Radium, 9. pp. 337–341, Oct., 1912.)—The experiments of v. Baeyer, Hahn, and Meitner, and later by Danysz [Abstracts Nos. 1349 (1911), 1194 (1912)] have shown that for many β-radiating products the β-rays are not altogether homogeneous but consist of a number of homogeneous groups of rays each of which is characterised by a characteristic velocity. This complexity appears to be best shown by products which also emit penetrating γ-rays. Using as a β-ray source a thin-walled glass tube containing a large quantity of RaEm, Danysz found that RaB and RaC together emit nearly 30 groups of homogeneous rays. Notwithstanding this great complexity the experiments of Moseley have shown that the actual number of β-particles emitted is about that to be expected if both RaB and RaC emit only one β-particle per disintegrating atom. In order to account for these results the author considers the hypothesis that the disintegration of each

atom of the same substance takes place in exactly the same way with the emission of the same amount of energy, but that the energy of the β-particle may be decreased by definite but different amounts due to the transformations of its energy in its passage through the atomic system in which it originates. The energy subtracted from the escaping β-particle in this way is further supposed to be transformed into the γ-rays. Evidence in support of this hypothesis is obtained from a consideration of Barkla's results on characteristic X-radiations, for the γ-rays of RaC have a coefficient of absorption in Al, in good agreement with that calculated for an atomic weight 214 by an extrapolation from the results for the elements examined, *i.e.* from Ca to Ce. An examination of the energies of the β-rays corresponding to the definite groups of velocity for RaB and RaC shows most of them to be expressible by the formula $pE_1 + qE_2$, where p has integral values between 0 and 9; q integral values from 0 to 2; $E_1 = 1{\cdot}12 \times 10^{13}e$ ergs and $E_2 = 0{\cdot}356 \times 10^{13}e$ ergs. The remainder, which presumably are those of RaB, show an approximately constant difference of energy $E_3 = 0{\cdot}173 \times 10^{13}e$ ergs. From the results of Whiddington and Chapman [Abstracts Nos. 1033, 1259 (1912), etc.] it is calculated that the energy of an electron necessary to excite the characteristic X-radiations of series K and L in an atom of atomic weight 214 are $1{\cdot}27 \times 10^{13}e$ and $0{\cdot}190 \times 10^{13}e$ ergs respectively, which are not very different from the above values of E_1 and E_3. Considering these results in relation to the author's theory that an atom consists of a central concentrated positive charge with rings of electrons round it possibly rotating in one plane, it is conceivable that the atomic instability which leads to the expulsion of a β-particle is mainly confined to one of the rings and leads to the escape of a β-particle from this ring with great velocity. The β-particle in escaping from the atom passes through the electronic distribution external to it, and in traversing each ring may in some cases lose part of its energy in exciting one or more γ-rays which have a definite energy characteristic of each ring. This idea finds general support from the known properties of γ-rays. E. M.

434. *Further Experiments on δ-Rays.* **N. Campbell.** (Phil. Mag. 24. pp. 527–540, Oct., 1912.)—The experiments show that, in the case of the current carried by δ-rays from metals, the relation between the current and the p.d. is independent of the temperature of the electrodes from the temperature of liquid air to the softening point of the glass used. Further, the current is determined rather by the total p.d. between the electrodes than by the electric field in the space between them. The author therefore concludes that the δ-rays must be emitted originally with a finite velocity. Most of the δ-rays appear to have velocities less than 3 volts, but a few may have velocities as high as 10 or 20 volts. The velocities, however, are independent of the material on which the α-particles fall and also of the velocity of the α-particles. The author does not consider it necessary to assume that all the δ-rays come from a layer of air on the surface of the materials. In a note the author states that results of further experiments have shown that Röntgen-rays liberate δ-rays precisely similar to those liberated by α-rays. E. M.

435. *Radio-activity of Terrestrial Surface Materials.* **J. Joly.** (Phil. Mag. 24. pp. 694–705, Oct., 1912.)—It has recently been well established that the fusion method of determining the Ra-content of rocks is more reliable than the old solution method and leads to somewhat higher values. In this method the emanation is taken directly from the pulverised rock while this is being decomposed by the alkaline carbonates at temperatures rising to

1100° C. or more. In the present paper results are given of many new determinations, and from these the subject of terrestrial radio-activity is discussed generally. For igneous rocks the mean Ra-contents per 10^{12} gm. are found to be : Acid, 3·01 ; intermediate, 2·57 ; basic, 1·28 ; general mean, 2·5. For sediments the mean is 1·5, and the measurements are such as to indicate a certain substantial difference between the two classes. For igneous rocks the rate of development of heat per gm. due to both Ra and Th is calculated to be $2{\cdot}5 \times 10^{-13}$ gm. cals. per sec. To account for the observed heat gradient at the surface of the earth a material of this degree of radio-activity can only be supposed to extend downwards to about 17 km. Various cognate questions are discussed, particularly relating to suboceanic sediments. E. M.

436. *Comparison of Coefficients of Diffusion of Thorium and Actinium Emanations, with a Note on their Periods of Transformation.* **M[ay] S. Leslie.** (Phil. Mag. 24. pp. 637–647, Oct., 1912.)—The values hitherto found for the diffusion coefficients of the radio-active emanations differ considerably from one another, and are in general higher than would be expected from the probable molecular weights calculated on the basis of the disintegration theory. The usual method employed in the cases of Th and Ac is to suspend a plate near the emanating substance for a time sufficient for the active deposit to attain equilibrium. The distribution of the active deposit at different distances from the source is measured and taken as proportional to the density of emanation atoms. The diffusion coefficient is calculated from the formula $p = p_0 e^{-\sqrt{(\lambda x/D)}}$, where p_0 is the initial concentration, p the concentration at a point of distance x, λ the radio-active transformation constant, and D the coefficient of diffusion. In the present series of experiments it is found that different results are obtained according as the plate is uncharged or is charged negatively, the difference being traced to diffusion of the active-deposit particles after their formation from the emanation atoms. Further, even with a charged plate the apparent diffusion coefficient obtained depends largely on the intensity of the source of emanation employed, the inference being that in presence of a large amount of ionisation some of the active-deposit particles are neutralised, and owing to their diffusion the gradient of active-deposit particles does not represent the true gradient of emanation, the difference depending largely on the arrangement of the apparatus. Maximum limits to the true values of the coefficients of diffusion for Th and Ac emanations are assigned to be 0·085 and 0·098 respectively. Experiments under as nearly identical conditions as the periods of the two emanations will allow, however, indicate that the molecular weights of the two gases are probably very nearly equal. In an additional note to the paper experiments are described in which the transformation periods of Th and Ac emanations are found to be 54 and 3·9 secs. respectively, in good agreement with the values generally accepted. E. M.

437. *Radio-activity of Hot Springs of Kinosaki, Tazima (Japan).* **D. Isitani and K. Manabe.** (Mathematico-Physical Soc., Tōkyō, Proc. 6. No. 21. pp. 308–312, Nov., 1912.)—The paper contains further results on the emanation-content of various waters [see Abstract No. 86 (1913)]. It is found that the greater the depth of an artesian well, the greater the emanation-content. This also explains results which show that hot springs contain much greater amounts of emanation than cooler ones. One particular spring at 63° C. gave 2700×10^{-12} curies of emanation per litre. E. M.

HEAT.

438. *Magnification of Capillary Thread of Thermometers.* **W. Meissner.** (Zeitschr. Instrumentenk. 32. pp. 371–376, Dec., 1912. Communication from the Physikal. Techn.-Reichsanstalt.)—Discusses the best form of prismatic cross-section for mercury-in-glass clinical thermometers in order to obtain as large as possible magnification of the capillary thread. A. W.

439. *Expansion of Water below 0° C.* **J. F. Mohler.** (Phys. Rev. 35. pp. 236–238, Sept., 1912. Abstract of paper read before the Amer. Physical Soc., Washington, Dec., 1911.)—Water in a capillary tube can be cooled considerably below 0° C. without freezing. Using this peculiarity the author enclosed freshly-distilled water in capillary tubes of diameters varying from 0·2 mm. to 0·4 mm. One end of a tube is sealed ; then the tube is immersed in a freezing mixture and the change in volume noted. In this way water was taken to — 13° C. without freezing, the volume becoming 1·003078 of its amount at 4° C. The changes in volume thus found are greater than those found for a shorter range by Desprez and by Pierre and Weidner. P. E. S.

440. *Thermal Conductivity of Metals.* **S. Pagliani.** (N. Cimento, 4. Ser. 6. pp. 482–497, Dec., 1912.)—Taking the best values obtained for various metals, the latter may be arranged in a series of decreasing thermal conductivity and reflecting power, or increasing emissive power. They then fall into groups according to the periodic system as follows : Ag, Cu, Au (1) ; Al (3) ; Mg, Zn, Cd (2) ; Rh, Pd, Ir, Pt, Fe, Ni (8) ; Mn (7) ; Sn, Pb (4) ; W, Mo, Cr (6) ; Va, Sb, Bi, Ta, Nb (5). The emissive power of many metals of the 5th and 6th groups has been utilised for incandescent filaments ; and the oxides of those of the 4th group for solid luminous conductors. E. E. F.

441. *Ratio of Specific Heats.* **A. Leduc.** (Comptes Rendus, 155. pp. 909–911, Nov. 4, 1912.)—Describes a new method for the determination of this ratio. A large flask is used provided with a tap. The temperatures are ascertained by a thermometer and the pressures of the contained gas inferred from the masses found by weighings of the flask at the different stages of the operation of filling and adiabatic expansion. Considerable accuracy is claimed for the method, and its mathematical theory is given. E. H. B.

442. *Emissivity of Solid and Liquid Gold.* **C. M. Stubbs** and **E. B. R. Prideaux.** (Roy. Soc., Proc. Ser. A. 87. pp. 451–465, Oct. 31, 1912.)—Describes a spectrophotometric comparison of the emissivity of solid and liquid gold at high temperatures with that of a full radiator, the measurements extending throughout the visible spectrum. A sharp discontinuity in the emissivity takes place at the melting-point, the liquid gold emitting more strongly than the solid in the red, and less in the extreme blue. The shape of the "relative emissivity" curves is quite different in the two cases. The curve of relative emissivity of solid gold at high temperatures is similar to that of absorptivity at low temperatures as determined from reflectivity measurements ; whether it is identical, in which case the temperature

coefficient of the absorptivity would be zero, could not be absolutely determined, owing to the change of structure which a polished surface undergoes on heating. No temperature coefficient of relative emissivity could be detected for the liquid metal, through a range of over 100°. Black-body temperatures of solid and liquid gold at the melting-point have been calculated. It is shown that the general equation expressing the radiation of a selective radiator is of the form $E_\lambda' = f(\lambda, T)c_1\lambda^{-5}e^{-c_2/\lambda T}$, which in the case of gold and other metals cannot be reduced to the form of Wien's equation for a full radiator with changed values of the constants. A. W.

443. *The Psychrometric Formula.* **G. Smeal.** (Roy. Soc. Victoria, Proc. 25. pp. 151–166, 1912.)—The observations discussed are in continuation of a series previously carried out to test a modification of the psychrometric formula proposed by Ekholm, viz. $x = \eta f - AB(t - t')$ [see Abstract No. 1491 (1912)]. The conclusion reached in the former paper was that the insertion of the coefficient η was not justified. The present work was undertaken in order to test the formula under low humidities, the former observations all having been made under conditions of fairly high humidity, that is, above 50 per cent. The range now covered is from 18 to 95 per cent. The method employed was exactly similar to that previously adopted, three wet bulb thermometers covered respectively with linen, cotton, and silk being used. The differences between the readings of these wet bulbs were again found to be quite unimportant and the conclusion is thus reached that the value of η is not perceptibly dependent upon the nature of the covering of the wet bulb. The most suitable values for η and A in the formula have been determined by the method of least squares and are found to be $\eta = 0{\cdot}9877$, $A = 0{\cdot}0006967$; while assuming η to be unity and applying the method of least squares to the determination of A in the simpler formula the value is found to be $A = 0{\cdot}0007232$. Applying each of these formulæ to the whole series of observations it is found that there is no practical difference in the accuracy obtained by the two methods for either vapour pressure or relative humidity. The formula $x = f - 0{\cdot}00072\ B(t - t')$ is therefore presented as that most satisfactory for general use. J. S. Dr.

444. *Specific Heats of Crystallised Salts.* **F. G. Jackson.** (Amer. Chem. Soc., Journ. 34. pp. 1470–1480, Nov., 1912.)—The author finds the following values for the specific heat of ice and of a number of crystalline salts :—

	− 78·4° to 0°	− 188° to 0°	− 188° to − 78·4°
Ice	0·424 ± 0·002	0·337 ± 0·001	0·277 ± 0·003 (calc.)
	− 78·4° to + 22°	− 190° to + 22°	− 190° to − 78·4°
$CuSO_4.5H_2O$	0·236 ± 0·001	0·202 ± 0·006	0·169 ± 0·007
$CuSO_4$	0·127 ± 0·008	0·120 ± 0·003	0·114 ± 0·010
$Cu(NH_4)_2(SO_4)_2.6H_2O$	0·249 ± 0·008	0·230 ± 0·004	0·212 ± 0·012
$CuNa_2(SO_4)_2.6H_2O$ ...	0·186 ± 0·010	0·153 ± 0·003	0·121 ± 0·013
$CuK_2(SO_4)_2.6H_2O$ ...	0·218 ± 0·001	0·174 ± 0·007	0·135 ± 0·008
$(NH_4)_2SO_4$	0 330 ± 0·001	0·283 ± 0·003	0·241 ± 0·004
Na_2SO_4.....	0·197 ± 0·006	0·167 ± 0·002	0·140 ± 0·008
K_2SO_4	0·171 ± 0·003	0·147 ± 0·008	0·125 ± 0·011
$ZnSO_4.7H_2O$	0·287 ± 0·001	0·215 ± 0·003	0·150 ± 0·004
$CdSO_4.{}^8/_3H_2O$	0·168 ± 0·001	0·135 ± 0·001	0·105 ± 0·002
$FeSO_4.7H_2O$	0·292 ± 0·002	0·234 ± 0·002	0·182 ± 0·004

The author has calculated the molecular heats, and finds that the molecular heats of hydrated and double salts are almost the same as the sum of the factors, except in the case of copper sodium sulphate. A. F.

445. *Free Electrons and Specific Heat.* **O. Richter.** (Ann. d. Physik, 39. 6. pp. 1590–1608, Dec. 23, 1912.)—A series of Bi-Sn and Bi-Pb alloys were examined with regard to their specific heat, in connection with Schulze's determinations of their thermal and electrical conductivity. The successive addition of Sn to Bi produces a uniform increase in the specific heat, whereas the successive addition of Pb to Bi produces a maximum of 0·032519 when equal weights are taken, with a straight slope either way. The departure from the rule of mixtures is in the opposite direction in the conductivities. The author concludes that in these two alloys, at all events, the free electrons do not sensibly contribute to the specific heat. E. E. F.

446. *Theory of Specific Heats.* **P. Debye.** (Ann. d. Physik, 39. 4. pp. 789–839, Nov. 12, 1912.)—A detailed review of the previous work, experimental and mathematical from which are drawn the following conclusions :— (1) For a solid body there is no simple frequency of the atoms as originally supposed by Einstein. The body is characterised rather by a whole spectrum of vibrations. (2) The spectrum consists of a finite number of lines, viz. three times the atomic number. The lines of the lowest frequency are the ordinary acoustical vibrations. (3) The falling-off of the spectrum may be characterised by the density of the lines estimated per change in frequency ($d\nu$). This is found to be proportional to $\nu^2 d\nu$. The proportionality factor is calculable from the elastic constants of the material. (4) From (3) a formula for the energy-content and for the specific heat may be derived, if in the sense of the *quantum* theory we ascribe to each degree of freedom the energy $h\nu/(e^{h\nu/kT} - 1)$, in which h = working quantum = $7{\cdot}1 \times 10^{-27}$ erg sec. k = Bolzmann's constant = $1{\cdot}47 \times 10^{-16}$ erg, T is absolute temperature. (5) For each monatomic body an expression is found for the specific heat which involves the ratio θ/T, where θ is a temperature characteristic of the body in question. The form of the function is the same for all monatomic bodies. (6) At low temperature the specific heat of *all* bodies is proportional to T^3. The energy-content is then proportional to T^4. The limiting law distinguishes the present author's results from the formulæ of Einstein and of Nernst and Lindemann. (7) The comparison of this formulæ with observations on diamond, Al, Cu, Ag, and Pb show a good accord. (8) The Nernst-Lindemann formulæ may be regarded as an approximation to that of the present author. (9) The characteristic temperature θ may be derived from the electric constants. [See Abstract No. 1707 (1911) and next Abstract.] E. H. B.

447. *Atomic Heats.* **W. Nernst** and **F. A. Lindemann.** (Preuss. Akad. Wiss. Berlin, Ber. 52. pp. 1160–1171, 1912.)—This is the sixth of a series of papers on specific heat investigations. It reviews the formulæ given by Einstein, the authors and P. Debye for specific heats [see preceding Abstract], also the results of experiment and theory for Al, Cu, Ag, diamond, KCl, and NaCl. [See Abstracts Nos. 1524 and 1707 (1911).] E. H. B.

448. *Chemical Affinities.* **W. Nernst.** (Preuss. Akad. Wiss. Berlin, Ber. 52. pp. 1172–1176, 1912.)—The seventh of the series of papers dealing with specific heats. This one discusses mathematically the relations between chemical affinity A, absolute temperature T, and the *Wärmetönung* U. E. H. B.

449. *Specific Heats of Solids at High Temperatures.* **M. v. Pirani.** (Deutsch. Phys. Gesell., Verh. 14. 23. pp. 1037–1054, Dec. 15, 1912.)—The

specific heats of tantalum and tungsten were determined by observing the energy necessary to heat the metal to a high temperature. The temperature was measured by a thermo-couple or by the charge of resistance of the metal with the temperature. The method was applied to the tantalum and tungsten filaments utilised in the manufacture of metallic filament lamps. For details the original paper must be consulted. [See also Abstract No. 250 (1908).] F. J. B.

450. *High-temperature Gas Thermometry.* **A. L. Day, R. B. Sosman, and E. T. Allen.** (Carnegie Inst. of Washington, Geophys. Lab. pp. 1–129, 1911.)—A complete record is given of the redetermination of the absolute temperature scale from 400° to 1100° and its extension to 1550°. The investigation extended over 5 years and included experiments with thermo-elements between zero and the temperature of melting Pt. The object of the gas-thermometer problem at present is to increase the accuracy of the measurements and to extend their range. Recent improvements have been : electric heating, resulting in accurate controlling of the temperature, and the use of the metal bulb with its definite and measurable expansion coefficient and its capability of holding the expanding gas without loss. The gas now used does not diffuse through the bulb or react with it chemically ; does not dissociate within the limits of practicable measurement, and its expansion can be expressed with reasonable certainty in terms of the Kelvin thermodynamic scale. The source of the errors in the thermo-elements, and a way to avoid them have also been discovered. In 1904 Holborn at the Reichsanstalt increased the range of the scale as far as 1600° C., the probable error of the new portion being 10°. The present publication is a record of experimental measurements covering an unusually wide range of details which do not admit of brief classification. The errors in previous work with the nitrogen thermometer have been reduced in the present investigation to about $\frac{1}{4}$th of their former magnitude, and the certainty of their evaluation is proportionately increased. The points chiefly attended to are the following : (1) To provide a uniform temperature about the bulb by a suitable arrangement of electric heating coils and diaphragms. (2) To enclose the furnace in a gas-tight bomb in which the pressure outside the bulb can be maintained equal to that within for all temperatures. The advantages are : (*a*) deformation of the bulb is avoided ; (*b*) by using the same gas within and without there is no tendency to diffuse through the bulb wall ; (*c*) the initial pressure may be varied within considerable limits, thus increasing the scope and sensitiveness of the manometer. The sensitiveness was about three times that of the Reichsanstalt. (3) The expansion of the bulb material was determined with great care and is probably accurate within 0·5 per cent. (4) The unheated space between the bulb and the manometer has been reduced until the total correction in this hitherto uncertain region amounts to less than 4° at 1100°. An error of 5 per cent. in the determination of its volume or temperature distribution is therefore practically negligible. These changes probably reduce the uncertainty in the correction factor required for the gas thermometer about 1100° to less than $\frac{1}{10}$th of its former magnitude. The chief source of present uncertainty is the temperature distribution over the surface of the bulb in an air-bath. For the higher temperatures no satisfactory liquid bath has been found. A table is given (as below) of standard melting-points with an estimate of the degree of trustworthiness to be accorded to each. Beside it is placed for comparison the present Reichsanstalt scale. No indication

of a limit to the temperature attainable with the nitrogen thermometer or to its ultimate accuracy was discovered during the investigation. [In a paper read before the Soc. franç. de Physique (Journ. de Physique, 2. Ser. 5. pp. 727–749, Sept.; 831–844, Oct., and pp. 899–911, Nov., 1912) the authors cover much the same ground, but more briefly.]

Substance.	Point.	Atmosphere.	Crucible.	Temperature.	Reichsanstalt Scale.
Zinc	Melting and freezing	Air	Graphite	418·2 + 0·3°	419·0°
Antimony	Melting and freezing	Carbon monoxide	,,	629·2 ± 0·5	630·6
Silver	Melting and freezing	Carbon monoxide	,,	960·0 ± 0·7	961·5
Gold	Melting and freezing	Carbon monoxide	,,	1062·4 ± 0·8	1064·0
Copper	Melting and freezing	Carbon monoxide	,,	1082·6 ± 0·8	1084·1
Diopside (pure)	Melting	Air	Platinum	1391·2 ± 1·5	
Nickel	Melting and freezing	Hydrogen and nitrogen	Magnesia and magnesium aluminate	1452·3 ± 2·0	
Cobalt	Melting and freezing	Hydrogen and nitrogen	Magnesia	1489·8 ± 2·0	1575
Palladium	Melting and freezing	Air	Pure magnesia	1549·2 ± 2·0	
Anorthite (pure)	Melting	,,	Platinum	1549·5 ± 2·0	
Cadmium	Melting and freezing	,,	Graphite	320·0 ± 0·3	321·7
Aluminium	Freezing	Carbon monoxide	,,	658·0 ± 0·6	657
Li_2SiO_3	Melting	Air	Platinum	1201·0 ± 1	
Platinum	,,	,,	—	{1752 / 1755} ± 5	

J. J. S.

451. *Constancy of Sulphur Point.* **W. Meissner.** (Ann. d. Physik, 39. 6. pp. 1230–1242, Dec. 23, 1912. Communication from the Physikal-Techn. Reichsanstalt.)—Discusses the various forms of screen and other arrangements needed for observing accurately the sulphur boiling-point. The paper is illustrated by a number of diagrams and gives tables showing the errors involved by certain modifications in the arrangements. These errors are often only a few hundredths of a degree. An equipment with electric resistance heating and a platinum-resistance thermometer is described in detail with a sectional figure. [See Abstract No. 1646 (1908).]

E. H. B.

452. *Change in the Boiling-points of Nitrogen Trioxide and Tetroxide on Drying.* **H. B. Baker** and **M. Baker.** (Chem. Soc., Journ. 101. pp. 2339–2341, Dec., 1912.)—A specimen of nitrogen trioxide which in 1907 failed to boil rapidly at 15° was kept for three years over phosphoric oxide and was then sealed off in bulbs by immersing the whole in liquid air, two of these being placed in tubes containing nitrogen dried by contact with phosphoric oxide. After six months the bulbs were broken and the boiling-point of the liquid at atmospheric pressure (757 mm.) was found to be 43° instead of −2°, which is the boiling-point of the ordinary liquid. On cooling the tube to +10° green drops formed at once, showing undissociated nitrogen trioxide to be present. When a small quantity of nitrogen, dried by passing through a long column of phosphoric oxide, was admitted to the apparatus the very small quantity of moisture it contained produced vigorous dissociation and the expansion blew out the stopper. It has also been found that dried

nitrogen tetroxide can be kept at a temperature of $+69°$ without boiling, although the ordinary boiling-point is $+22°$. The explanation of these abnormal boiling-points is probably to be found in the difference of complexity in the liquids. It is probable that the liquid nitrogen trioxide has a more complex molecule than N_2O_3, and in one case the vapour density indicated a mixture of three molecules of N_4O_6 with one of N_2O_3. It is further possible that a more complex molecule exists in the liquid below $-2°$, since the colour changes distinctly from olive-green to bright blue at this temperature. Further experiments are being made on the boiling-points of dissociable substances.

T. H. P.

453. *Some Physical Constants of Sulphur Trioxide. Melting- and Boiling-points, Density, Coefficient of Expansion, and Molecular Weights.* **D. M. Lichty.** (Amer. Chem. Soc., Journ. 34. pp. 1440–1448, Nov., 1912. Paper read at the 8th Internat. Congress of Applied Chemistry, New York, Sept., 1912.)—The author finds the melting-point of α-sulphur trioxide under atmospheric pressure to be 16·79°. The boiling-point was found to be 44·23° at 740·7 mm.; 44·21° at 740·0 mm.; 44·36° at 744·5 mm. From these values the b.p. at 760 mm. is calculated to be 44·88°, in place of 46°, the value usually given. The values for the density are as follows :—

Temp.	11·8°	15°	20°	25°	30°	35°	40°	46°
Density	1·9457	1·9422	1·9229	1·9020	1·8798	1·8569	1·8324	1·7921

The coefficients of expansion are also given for a series of temperature-ranges, *e.g.* between 15° and 20° it is 0·002005, between 20° and 25° 0·002204. The author does not find that there is any temperature at which there is a slow attainment of constancy of volume at fixed temperature such as was found by Schenck at 35·3°. He shows that there exists a solid sulphur trioxide, apparently identical with the ordinary solid form, and designated the β-form, the molecular weight of which in phosphorus oxychloride is 80, the same as that of the persistently liquid α-variety. A. F.

454. *On the Triple Point of Methane.* **C. A. Crommelin.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. p. 666, Nov. 28, 1912. Communication No. 131B from the Physical Lab., Leiden.)—The following values of temperature and pressure at the triple point of methane were found: $t = -183·15$ K.; $p = 7·0$ cm. A. F.

455. *On the Second Virial Coefficient for Diatomic Gases.* **W. H. Keesom.** (Konink. Akad. Wetensch. Amsterdam, Proc. 15. pp. 417–431, Oct. 24, 1912. Supplement No. 25 to communications from the Phys. Lab., Leiden.)—The most important results yielded by the present investigation are summarised as follows :—The experimental results with regard to the second virial coefficient for hydrogen above $-100°$ C. are consistent with the assumption of rigid spheres with constant doublets. Below $-100°$ C. hydrogen exhibits deviations from this behaviour which finally become considerable. Below the Boyle point hydrogen is found to correspond with argon and also with helium in so far as the experimental data for helium at present available allow of any definite conclusion. It appears, therefore, that between $-100°$ C. and $-230°$ C. as far as B is concerned the thermal behaviour of hydrogen also approaches that of a monatomic substance and eventually becomes the same, as was found by Eucken to be the case with its caloric behaviour. It was also found that, as far as the second virial coefficient is concerned the thermal

behaviour of oxygen between 0° and 200° C., as deduced from Amagat's observations, corresponds with that of a system of rigid spheres of central symmetry, each with a doublet of constant moment at its centre. For nitrogen, on the other hand, within the same temperature region, important deviations were found from the behaviour of rigid spheres of central structure each with an electric doublet of constant moment at its centre. With nitrogen in that temperature region, the dependence of B on the temperature corresponds with that deduced from the assumption that the van der Waals quantities a_w and b_w are constant; but then the values given by Bestelmeyer and Valentine for B from 81° to 85° K. differ greatly from this. A. F.

456. *Heat of Vaporisation of Metals.* **A. Wehnelt** and **C. Musceleanu.** (Deutsch. Phys. Gesell., Verh. 14. 22. pp. 1032–1034. Nov. 30, 1912.)—The method adopted is to use the metal as anode in a vacuum tube. The kathode consists of platinum foil of suitable size on which CaO is placed. It is so arranged that the max. electrical energy occurs at the anode, so as to bring about the melting and vaporisation of the metal under observation. The anode is weighed before the experiment, and then by means of the loss of weight, and calculations based upon the energy used in vaporising the metal, the total heat and the latent heat of vaporisation are determined. The results so obtained are as follows :—

Metal.	Measured Total Heat of Vaporisation.	Latent Heat of Vaporisation Calculated from Total Heat.
Hg	73·8	63·6
Cd	222·0	181·0
Zn	439·5	365·8
Mg	2027·0	1700·0
Bi	177·5	161·5

A. E. G.

457. *New Forms of Whirling Gaseous Combustion and their Analogy with certain Astronomical Phenomena.* **J. Meunier.** Comptes Rendus, 155. pp. 1243–1246, Dec. 9, 1912.)—When a gas jet is brought up to a wide flame, the gas-pressure of which has been increased to one-tenth of that of the jet [see Abstract No. 883 (1912)], the point of the latter is bent back owing to the resistance of the non-inflammable interior of the other flame. The luminous centre of the spiral undergoes circular enlargement and exhibits a brilliancy showing regular alternations which recall the phenomena observed with temporary stars; its colour varies from yellow to reddish. A mechanical explanation is suggested for these flame phenomena, which are compared with those of spiral nebulæ. T. H. P.

458. *Ignition of Electrolytic Gas by the Electric Discharge.* **H. F. Coward, C. Cooper,** and **C. H. Warburton.** (Chem. Soc., Journ. 101. pp. 2278–2287, Dec., 1912. —The ignition temperature is the lowest temperature at which the rapid inflammation of a gas mixture occurs in the absence of a catalyst. The experiments concern chiefly the minimum gas-pressure at which ignition occurs with different spark-gaps and batteries in different-

sized vessels. The size and shape of the vessel (cylinder or globe of glass) have no influence except at very low pressures (5 to 10 mm.) and in very small vessels, nor has the position of the electrodes in the vessel. The ignition pressure is lowered by covering the electrodes with glass except the tips, especially when the bare tips are enlarged. As the spark-gap is lengthened the ignition pressure passes through a minimum. A flame which filled a globe of 570 cm.³ has been produced at 5 mm. a flame which travelled through a cylinder, 2 m. long, at 8 mm. pressure: these figures are considerably lower than previous observations. The combustion is never complete because of the cooling effect of the glass walls and the amount of the unburnt gas varied in two globes inversely as the initial pressure of the gas. H. B.

459. *The Gas Equation.* S. D. Wicksell. (Phil. Mag. 24. pp. 369–376, Dec. 1912.)—Expressing the constants a and b in van der Waals' gas equation as functions of the temperature thus getting a gas equation that covers the case of Clausius and others. The equation is put into a more convenient form by means of series and a and b are expressed in terms of known and measurable quantities. That the deviation from the ideal gas equation is proportional to the pressure is expressed by the relation—

$$P'v' - R\theta/P'v'' - R\theta) = P'/P''.$$

This equation includes no quantity characteristic of the gas, and therefore can be regarded as a general gas law to a second approximation, if Boyle-Mariotte-Gay Lussac's law is regarded as the first approximation. E. E. F.

460. *Constant of the Stefan Law of Radiation.* W. H. Westphal. (Deutsch. Phys. Gesell. Verh. 14. 21. pp. 997–1012, Nov. 15, 1912.)—The constant of the Stefan radiation law was determined from measurements of the consumption of electric energy of a blackened body radiating heat in air at low pressure, the temperatures ranging from 350° to 425° abs. The effect of heat conduction of the air was eliminated by a difference method. The mean of all the results obtained gives for the constant the value $\sigma = 5{\cdot}54 \times 10^{-12}$ watt/cm² deg⁴ ± 0·5 %. From Planck's radiation theory and the value for σ using the value $b = 1{\cdot}437$ found by Warburg, Hupka, and Müller, the following constants are determined:—

Elementary quantum of electricity	$e = 4{\cdot}68 \times 10^{-10}$ e.s. unit.
Constant of entropy equation	$k = 1{\cdot}341 \times 10^{-16}$.
Elementary "Wirkungsquantum"	$h = 6{\cdot}455 \times 10^{-27}$.
Number of molecules per c.cm. of a gas	$N = 2{\cdot}77 \times 10^{19}$.

A. W.

461. *Calculation of Internal Energy from the Characteristic Equation.* E. Kohl. (Monatshefte f. Math. u. Physik, 24. pp. 159–182, 1913.)—In a previous paper the relationship $P = T\int_{T_0}^{T} \frac{\partial^2 \epsilon}{\partial T^2}\,dT + T\frac{\partial \epsilon}{\partial T}$ was established where P is the reversible pressure, ϵ the internal energy, V the volume, and T the temperature of a body. The integration is carried out with ϵ as a function of T and V, V being a parameter of T. The assumption of ϵ as a function of T and V is the basis of the author's deductions. By inserting the above value for P in the Clausius modification of the characteristic equation, expressions for the heat of evaporation, the specific heats at constant volume and pressure, and the heat of compression at constant

temperature are obtained. As examples the heats of evaporation of ethyl ether, water, carbon disulphide, and ethyl alcohol are discussed, and the values obtained compared with those afforded by the formulæ of Hirn and Winkelmann. For ether and water the values diverge with increasing temperature, for carbon disulphide the formulæ are in excellent agreement while for alcohol the disparity between theory and experiment is most pronounced. The specific heats for the same four liquids are also considered. From the results the author concludes that the internal-energy expression rests on firm ground, and that any deviation between theory and experiment is due to inexactness of the modified characteristic equation. The internal energy thus appears to be a definite function of T and V, whose form depends upon the nature of the substance. H. H. Ho.

462. *Radiation Theory.* **D. Hilbert.** (Phys. Zeitschr. 13. pp. 1056–1064; Discussion, p. 1064, Nov. 1, 1912. Paper read before the 84. Naturforscher-versamml. Münster, Sept., 1912.)—A treatment of the foundations of elementary radiation theory by aid of integral equations. The most important of Kirchhoff's laws is thus obtained as a mathematical truth, from which the other laws then follow. E. H. B.

463. *Universal Significance of the Elementary Working-quantum.* **O. Sackur.** (Deutsch. Phys. Gesell., Verh. 14. 21. pp. 951–959, Nov. 15, 1912; Ann. d. Physik, 40. 1. pp. 67–86, Dec. 31, 1912.)—A mathematical treatment regarding the entropy constants of gases, and using Sommerfeld's hypothesis that every action exerted in nature is an integral multiple of the elementary working-quantum (*Wirkungsquantum*) *h*. The analysis leads to an equation expressing the vapour-pressure at different temperatures, which, on comparison with calorimetrically determined quantities, gives a new and direct confirmation of Nernst's theorems. E. H. B.

464. *Photochemical Law and the Molecular Theory of Radiation.* **J. Ishiwara.** (Phys. Zeitschr. 13. pp. 1142–1151, Dec. 1, 1912.)—A theoretical treatment on thermodynamic lines with special reference to Einstein's work. [Abstract No. 1689 (1912).] L. H. W.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

465. *Magnetic Effect of Rotating Bodies.* **P. Lebedew.** (Ann. d. Physik, 39. 4. pp. 840–848, Nov. 12, 1912.)—Describes experiments designed with the view of detecting a distant magnetic effect, if any exists, of rotating bodies. With rings of ebonite, brass, aluminium, water, and benzol *no perceptible* deflection of the magnetometer was obtained. E. H. B.

466. *Charges on Metallic Dust.* **A. Mayer.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1097–1133, June, 1912.)—An endeavour to harmonise the results of E. Ehrenhaft and of R. H. Millikan on the determination of the elementary electric charges on very fine particles of metal. The data of the above experimentalists are repeated and examined in detail, but no definite quantitative result is derived from them. [See Abstract No. 1560 (1912).] E. H. B.

467. *Nuclei Charges.* **K. Przibram.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 949–984, June, 1912.)—A summary of the data from previous experimental papers and a derivation therefrom of the elementary electric charge. The values differ according to whether one or another correction to Stokes' law is used. Thus Millikan's correction is characterised by $A = 0{\cdot}815$, McKeehan's by $A = 1{\cdot}00$. On Stokes' law $A = 0$, yet other views give $A = 0{\cdot}68$ and $A = 1{\cdot}3$. The final means are as follows:—

Values of A : 0·815, 1·0, 1·3,
Values of $e \times 10^{10}$: 4·957, 4·600, 4·21.

The paper contains about 25 pages of tables. [See Abstracts Nos. 636 (1911); 57 and 354 (1912).] E. H. B.

468. *Electrification by Spraying Liquids.* **C. Christiansen.** (Ann. d. Physik, 40. 1. pp. 107–137, Dec. 31, 1912.)—This paper deals with a series of researches on the electrification occurring when fine drops of liquid are squirted on to a solid wall, by Lenard called *waterfall* electricity, the present author preferring the term *Balloelektrizität*. This is the first communication of a series and presents in 41 tables the results of tests on a great number of liquids. E. H. B.

469. *Problems relating to Two Spheres.* **G. B. Jeffery.** (Roy. Soc., Proc. Ser. A. 87. pp. 109–120, Aug. 13, 1912.)—A form of the solution of Laplace's equation suitable for problems relating to two spheres is found. The solution is applied to finding expressions for the potential and capacity of two spherical conductors. Tables of the numerical values of the capacity coefficients for two equal spheres are given and also a table for the capacity of a sphere in the presence of an infinite conducting plane. **A. Russell.** (Ibid. pp. 485–487, Dec. 13, 1912.)—Russell shows that the numerical values of the capacity coefficients for equal spheres can be computed very easily when the spheres are close together. He recalculates the tables and gives a formula for calculating the capacity between a sphere and a plane when they are very close together. A. R.

470. *Determination of Electrostatic Capacities by Conjugate Functions.* **J. W. Woodrow.** (Phys. Rev. 35. pp. 434–448, Dec., 1912.)—The author obtains by means of conjugate functions the formula for the capacity, (1) of a wire parallel to two planes intersecting at right angles, (2) of two wires parallel to the earth and one directly above the other, and (3) of three parallel wires arranged so as to be at the corners of an equilateral triangle. He finds the capacity of a two-core cable by a suitable transformation and also finds the capacity of the three-core clover-leaf type of cable discussed in Russell's "Alternating Currents," Vol. I., Chap. V. A. R.

471. *The Problem of Two Electrified Spherical Conductors.* **G. R. Dean.** (Phys. Rev. 35. pp. 459–469, Dec., 1912.)—The author by a suitable transformation of Laplace's equation obtains a solution for the potential at all points in the neighbourhood of two electrified spheres having unequal radii. The solution is in the form of an infinite series of zonal harmonics. All the mathematical work is clearly given and simplified formula are found both for the potential and the potential gradient in the neighbourhood of two equal spheres having equal and opposite charges of electricity. A. R.

472. *Dust Figures produced by Electric Sparks.* **E. H. Barton** and **W. B. Kilby.** (Phil. Mag. 24. pp. 728–736, Nov., 1912.)—Lycopodium powder was used to obtain striæ by means of electric sparks from an influence machine or induction coil, the support being glass or metal. The striæ showed many analogies to optical phenomena, including reflection, refraction, interference, and diffraction. Distinct foci were obtained by reflection from concave surfaces. A "whispering gallery" effect was observed in the shape of striæ normal to a surface for a considerable distance, without divergence of the wave-normals. Twenty reproductions of these dust figures are given. E. E. F.

473. *High Value of Induced Radio-activity and of Conductivity in the Cordilleras.* **W. Knoche.** (Phys. Zeitschr. 13. pp. 1221–1222, Dec. 15, 1912.)—Observations of radio-activity by Elster and Geitel's method at the mine Las Conde near Santiago (3500–3600 m. above sea-level) gave very large values, and observations of conductivity on clear and dry days gave a mean value of about 23×10^{-4} e.s. unit. The high conductivity was a consequence of the presence of an abnormally large number of ions, while at the same time the velocity of the ions was not far from normal. Probably the large values are due to the high altitude and to intense solar radiation. R. C.

474. *Atmospheric Electricity. Observations at Seeham in Summer,* 1911. **E. v. Schweidler.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1297–1304, July, 1912.)—The observations [see Abstract No. 190 (1912)] were continued in July to Sept., 1911. The dissipation curves of 1911 (very dry, hot summer) differed from those of previous years as to the diurnal variations. The ionisation due to the penetrating radiation was measured in a zinc vessel, not hermetically sealed, and in a copper vessel, hermetically sealed, on shore, in the air above the lake and also in the shallow water of the lake (Mattsee); the two apparatus did not agree, even when close to one another. There was a decrease of the radiation above the water and an increase after rain; the radiation at Seeham was much smaller than at Innsbruck. H. B.

475. *Measurements of Atmospheric Electricity during the Partial Solar Eclipse on April* 17, 1912. **A. Brommer.** (Akad. Wiss. Wien, Ber. 121. 2a.

pp. 985–995, June, 1912. Communication from the Inst. f. Radiumforschung.) —Observations of atmospheric electricity made during previous solar eclipses have yielded contradictory results in the hands of different experimenters and on different occasions, and have given rise to the belief that no direct connection exists between the variations in solar radiation and the electric elements. Observations were made by the author of the numbers and velocities of the positive and negative ions in the atmosphere near Vienna at intervals during the day of the eclipse and the following day. Meteorologically both days were similar, as they opened with light clouds, which gradually cleared away in the afternoon. On the 17th April a slight increase in relative humidity took place during the time of eclipse, otherwise there was nothing specially remarkable about the meteorological records. Of the electrical measurements the most noteworthy were those of positive and negative charge per m.^{3}, which are proportional to the numbers of positive and negative ions. The positive charge showed a gradual decrease from 0·54 to 0·26 e.s. unit near the time of maximum phase, followed by an equally gradual increase to 0·52 at the end of the eclipse. The negative charge showed similar characteristics, the corresponding values being 0·52, 0·22, and 0·54. The variations before and after the eclipse were slight, and they were small and irregular on the following day. The velocities of the ions decreased slightly during the first part of the eclipse, and remained steady afterwards. On both days the positive usually exceeded the negative charge and the value of q, the ratio of positive to negative charge, was therefore usually greater than 1 ; but large variations in this quantity occurred at the beginning and towards the end of the eclipse. The variations in the charges are so well defined and regular that the author finds it difficult to avoid the conclusion that there was a *direct* connection between the eclipse and the number of ions. R. C.

476. *Variations of the Electrical Conductivity of the Atmosphere and of the Air-earth Current at Potsdam.* **K. Kähler.** (Phys. Zeitschr. 13. pp. 1216–1221, Dec. 15, 1912.)—Continuous registration of electrical conductivity as well as potential gradient and charge on rain has been made at Potsdam since 1909. For recording conductivity two blackened copper wires 20 m. long are suspended horizontally between hard rubber insulators and connected each with a Benndorf electrometer. The upper wire, which is charged positively, is 1½ m. above the ground ; the lower, negatively-charged wire is 1 m. below the upper, *i.e.* ½ m. above the ground. Each wire is surrounded by an earthed wire-netting ½ m. away. Six times an hour the wires are charged up to + 220 and — 220 volts respectively, and the fall of potential during the 10 mins. succeeding each charge is recorded by the electrometer, and therefrom the conductivities of the negative and positive ions (λ_- and λ_+) are deduced. On "quiet" days the mean conductivity ($\lambda_+ + \lambda_-$) is $0{\cdot}95 \times 10^{-4}$ e.s. unit, the mean potential gradient is 254 volts/m., and the mean value of q ($= \lambda_+/\lambda_-$) is 1·16. From the mean values of conductivity and potential gradient is deduced the mean air-earth current. It amounts to 71×10^{-8} e.s. unit, *i.e.* $2{\cdot}4 \times 10^{-16}$ amp./cm.^{2}. Solar radiation is found to exercise a powerful influence upon the variations of the electric elements. For example, the seasonal variation of air-earth current shows a maximum in winter or spring, and a minimum in summer or autumn ; and the daily variation in summer has a pronounced minimum in the mid-day with maximum in the evening and morning. The excess of positive ions is greater in winter than in summer and smaller at mid-day than at night, q is smaller at

mid-day near the ground than higher up. Fog almost always produces a large diminution in conductivity, while dust frequently causes the potential gradient to become negative, without affecting the conductivity. This appears to be due to very immobile ions. R. C.

477. *Stokes' Law and Electronic Charge.* **J. Roux.** (Comptes Rendus, 155. pp. 1490–1493, Dec. 23, 1912.)—Discusses a correction to Stokes' law and the percentage difference it would introduce in the value obtained for the electronic charge on Millikan's plan. [See Abstract No. 943 (1911).] E. H. B.

DISCHARGE AND OSCILLATIONS.

478. *Gas Ionisation by the Schumann Rays.* **L.** and **E. Bloch.** (Comptes Rendus, 155. pp. 903–906, Nov. 4, 1912.)—Ordinary ultra-violet rays produce the Hertz-effect when they strike a metal, but do not ionise dust-free air. The author finds that the Schumann rays produce by ionisation an effect at least five times greater, at atmospheric pressure, and 25 times greater at pressures of 3 cm., 2 cm., 1 cm. than the Hertz-effect of ordinary rays. In a vacuum the ionisation ceases, but the Hertz effect of the Schumann rays is at least five times greater than that of ordinary rays. J. M.

479. *Ionisation of Air by Quartz Mercury Arc.* **L.** and **E. Bloch.** (Comptes Rendus, 155. pp. 1076–1078, Nov. 25, 1912.)—Preliminary experiments showed that the photoelectric effect on brass of the light from a Cooper Hewitt mercury lamp is reduced very considerably by the interposition of a quartz plate 1 mm. thick, and that a plate of 0·25 mm. produced a sensible diminution. The rays intercepted are evidently those which have been separated spectroscopically by Tian [see Abstract No. 1357 (1912)], and which correspond to the beginning of the absorption band of quartz. These rays are only feebly absorbed by air, for in the authors' experiments there was a distance of about 1 m. between the arc and the photoelectric receiver. But it was thought these rays, or others more refrangible, might cause appreciable ionisation of the air in the neighbourhood of the arc. The arc was enclosed in a zinc box, which had two openings, one for ingress, the other for egress of air. Through the box was sent a current of filtered air, which passed thence to a condenser connected to an electrometer. As soon as the arc was started, the condenser received electric charges. Measurements were carried out exclusively on the positive charges, whose presence is a certain indication of volume ionisation. These charges could not be attributed to diffused ultra-violet light, which was eliminated as completely as possible; and no effect was produced in absence of the current of air; also it was not due to the high temperature of the quartz tube, for this was kept from getting too hot. The electrometer deflection followed almost instantaneously the striking of the arc. It is concluded that the light from the mercury arc can ionise air, and that the ionising action shows itself for the rays which are far from being entirely absorbed by quartz. [See preceding Abstract.] A. W.

480. *Simultaneous Action of Magnetism and Gravitation upon Ionised Gases.* **Gouy.** (Comptes Rendus, 155. p. 1060, Nov. 25, 1912.) **C. G. Darwin.** (Ibid. pp. 1145–1146, Dec. 2, 1912.)—Gouy mentions that the apparent failure of Carnot's principle [see Abstract No. 216 (1913)] will not occur if the ions are generated on the walls of the vessel, say, at a high temperature. Then

the motion of the ions from the bottom will be opposed to that of the ions in the middle of the gas, and an exact compensation may take place. Darwin adduces reasons why Carnot's principle should remain valid in any case. Liouville's dynamical theorem is not affected by the presence, in the equations of motion, of gyrostatic or magnetic terms. If, then, the distribution of ions and molecules is fortuitous to begin with, there will be no tendency to a systematic or non-fortuitous distribution, and therefore there will be no separation of the ions, and no "spontaneous" current. E. E. F.

481. *High Velocities of Photoelectric Electrons.* **R. Pohl** and **P. Pringsheim.** (Deutsch. Phys. Gesell., Verh. 14. 21. pp. 974–982, Nov. 15, 1912.)—Millikan obtained values ranging from 10 to 100 times those formerly observed for the initial velocity of electrons set free by the action of ultra-violet light of wave-lengths 180 to 300 $\mu\mu$. Experiments are now described which indicate that these abnormal velocities are to be attributed to the disturbing action of electric oscillations. A. E. G.

482. *Ionisation and Photo-electricity of Vapours of Alkali Metals.* **S. H. Anderson.** (Phys. Rev. 35. pp. 239–264, Oct., 1912.)—When potassium vapour alone is between the electrodes (Ni electrodes used) of a vacuum tube there is no conductivity of the usual type at 25° or 50°. At 100°, with a p.d. of 700 volts, there is a current arising from ionisation by the electric field. There is nothing of the character of spontaneous ionisation. In a tube with two similar electrodes, exhausted to the highest vacuum, there is a current of the order of 10^{-18} amp. in a direction opposite to the electric field, which increases with the field. This phenomenon is affected by light and is diminished by the presence of K-vapour. It confirms Woodrow's observation of the emission of +-particles from alkali metals. At temperatures above 50° this emission is, in the dark, large compared with the electron current. But for higher temperatures the emission of electrons is predominant for p.d.'s of 300 volts and more. Probably the critical temperature is 62°, the melting-point of K. At 25° the photoelectric current is 25 times the current due to the emission of +-particles, but at higher temperatures it becomes very small in comparison with the positive emission, unless an auxiliary voltage is applied. The max. vapour pressure possible for K at 25° is 0·0587 mm. of Hg. E. E. F.

483. *Theory of Photoelectric Action.* **O. W. Richardson.** (Phil. Mag. 24. pp. 570–574, Oct., 1912.)—Gives a second theory [see Abstract No. 1414 (1912)] which covers more facts than the first. This solution is dependent on the assumption that the reflection of electrons can be neglected. This means that the only energy lost by the electrons is used up in overcoming the work of the forces which tend to retain them within the interior of the substances. Then the kinetic energy of the escaped electrons is equal to that which they acquire by the action of light *minus* the work which they have to do to escape. It is clear that the energy which they acquire under the influence of light is $h\nu$, where h is Planck's action constant. It has the same value for all the electrons liberated by light of the same frequency; any difference in the energy of the electrons liberated by monochromatic light is therefore due to the effect of collisions of the escaping electrons within the substance. E. E. F.

484. *Reflection of Slow Kathode Rays.* **L. Houllevigue.** (Comptes Rendus, 155. pp. 1146–1149, Dec. 2, 1912.)—The author has previously shown [see

Abstract No. 1085 (1912)] that the electrons emitted by an incandescent carbon filament can give under the action of an electric field created by a p.d. of about one hundred volts, a very clearly outlined kathode bundle. Experiments are now described which show that by systematically varying the electric state in the interior of a receiver the effects of apparent reflection of a kathode bundle can be reproduced at will, as can also the suppression of this reflection. There is thus no doubt that the observed reflection at the internal surface of the glass is due to the fact that this surface is maintained at a certain critical potential, and that this result is brought about automatically by successive reflections. When the glass is at a potential higher than the critical value it absorbs the electrons, and a lowering of potential is thus brought about: this goes on until the potential is reduced to the critical value when reflection again takes place. These successive reflections at the interior of a receiver give birth to a diffused light: when the kathodic bundle is no longer reflected the light disappears. A. E. G.

485. *Light given out by Gases under the Influence of Kathode Rays.* **E. Gehrcke** and **R. Seeliger.** (Deutsch. Phys. Gesell., Verh. 14. 22. pp. 1023–1031, Nov. 30, 1912. Communication from the Physikal.-Techn. Reichsanstalt.)—This forms a continuation of experiments previously described [see Abstract No. 908 (1912)], improved apparatus being used by means of which the paths of the kathode rays are greatly elongated. In the first part, observations of the colour envelope of the kathode rays in nitrogen, hydrogen, helium, argon, mercury, CO, and coal gas lead to the conclusion that, in general, elongated kathode rays show a threefold colour envelope. The colours observed depend upon the pressure and the current. Comparative experiments on the positive column in nitrogen, hydrogen, mercury, and helium are next described. Every light-striation has in general three different coloured parts. The sharpest formed layers occur in hydrogen and the least sharp in helium; in the latter the colour and form is very variable. From the results it is also clear that the colour series of the separate parts of a layer are not always in accord with those of a lengthened-out or accelerated kathode ray. Lastly the spectra of different parts of an elongated kathode ray in hydrogen, nitrogen, helium, and mercury are examined. These observations show that the colour envelope of the lengthened-out kathode rays depends on the properties of the luminous particles. A. E. G.

486. *Absorption of Gas in Vacuum Tubes.* **S. E. Hill.** (Phys. Soc., Proc. 25. pp. 35–43; Discussion, p. 43, Dec., 1912. Electrician, 70. pp. 228–229, Nov. 15, 1912. Abstract.)—It has long been known that the continuous discharge of a current through an ordinary vacuum tube causes a gradual diminution of pressure. No experiments have yet been described which enable it to be determined whether this action is of a chemical nature or merely due to physical absorption. In the present experiments the electrodeless ring discharge is used because the ions are not shot directly into the glass as in the case with metal electrodes, and any possibility of electrode action is done away with, both as regards absorption and evolution of gas. The bulbs used are made of soda, Bohemian, lead, and Jena glass, and the absorptions at different pressures are noted and curves plotted. Continued passage of the current causes a "saturation" effect in all these glasses. The decreasing order of absorption for both air and hydrogen is: soda, lead, Bohemian, Jena. After two months none of the bulbs had recovered their absorptive power. If the action is chemical it is natural to expect various oxidation products to be

formed when air is used. This is proved to be the case, for when tested with hydrogen to reduce these products, a large initial absorption takes place. That reduction actually occurs is proved by the increased absorption of oxygen when air is readmitted. The peculiar deposits on the necks of the bulbs is further evidence in support of the chemical nature of the phenomenon, as is also the fact, established by Soddy and Mackenzie, that the inert gases show correspondingly small absorption. In the *discussion*, **A. A. Campbell Swinton** pointed out that in Soddy's and the present experiments, forms of electric discharge were employed with which the amount of heat communicated to the glass would be very great as compared with the amount of kathode-ray bombardment ; whereas in his experiments the converse was the case. He therefore thinks it probable that the cause of the absorption of gas is not necessarily the same in both cases. A. E. G.

487. *Influence of Nature of Kathode on the Length of the Crookes Dark Space.* **F. W. Aston.** (Roy. Soc., Proc. Ser. A. 87. pp. 437–451, Oct. 31, 1912.)—The kathode-fall is widely different for different metals, and it was thought probable that the length of the dark space might also be affected. On this account the following metallic kathodes are experimented with : Mg, Al, Fe, Cu, Zn, Ag, Sn, Pt, and Pb, and in addition kathodes of C, Hg, H_2SO_4 and also perforated kathodes of Zn are used. The gases employed are oxygen and hydrogen, the former on account of the abnormal sharpness of the edge of its dark space, the latter for contrast and because it exhibits the primary kathode dark space ; the anode throughout is of Al. A simple form of apparatus, particularly adapted for changing the kathode with minimum risk of accident, is described. Results obtained show that the relations between the values of pressure, voltage, current and the length of the dark space as determined for plane kathodes of many different materials, satisfy the same form of equation as those previously given for Al, the constants varying considerably. Roughness of the kathode surface does not appear to affect the discharge, if the dimensions of the irregularities are small compared with the length of the dark space. The length of the dark space is shown in the cases examined to be greatest for Ag and least for Mg, the metals following the same order as in the kathode-fall. The rate of change of length of the dark space with change of current density at the surface of the kathode appears to be the same for all kathodes. Difficulties in the way of arriving at a satisfactory explanation of these and other data connected with the dark space are indicated and briefly discussed. A. E. G.

488. *Observations on the Glow Discharge in very Pure Gases.* **G. Gehlhoff.** (Deutsch. Phys. Gesell., Verh. 14. 21. pp. 960–969, Nov. 15, 1912.)—Gehlhoff and Rottgardt found that in the presence of vapours of the alkali metals the kathode-fall and the discharge potential in a vacuum tube were very small [see Abstract No. 1315 (1910)] ; and, further, the author has found that potassium vapour purifies the gas. It might therefore be expected that the low kathode-fall and total potential is caused by a purification of the gas by the electric discharge in potassium vapour and the deposit of metallic potassium on the kathode. The present experiments establish these assumptions and at the same time show in what a very marked degree the electrical properties of a gas depend upon its purity. Thus in pure hydrogen the striations are not removed, while in pure gases of the He group and in pure nitrogen a completely unstriated discharge occurs. A. E. G.

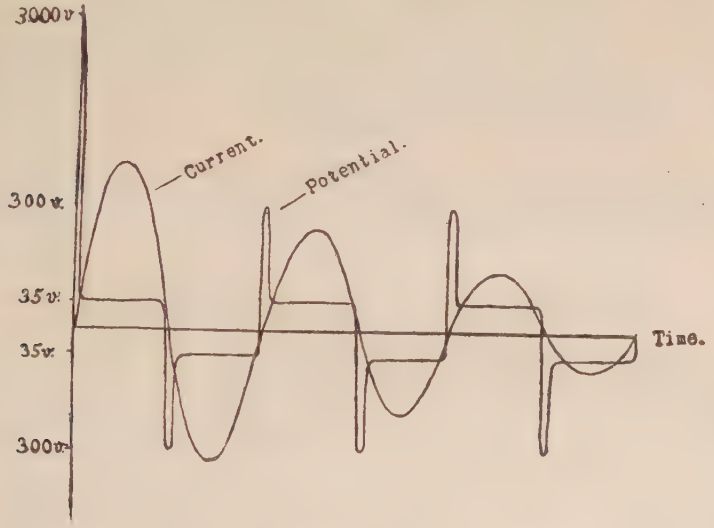
489. *Phenomena of Electric Pseudo-resonance.* **G. Claude.** (Comptes Rendus, 155. pp. 968–971, Nov. 11, 1912.)—When neon tubes are connected in series with condensers, it has been found that as the number of these tubes increases, the current intensity also increases: thus, with the condenser there is a current of 0·7 amp.; with one tube, 0·88 amp.; 1·10 amps. with two, 1·22 with three, and 1·26 amps. with four tubes in series. A fifth tube not only makes it difficult to illuminate, but causes a diminution of the current. It is further found, when the light of one of the tubes is examined photometrically, that although the current increases enormously the luminosity of the tube diminishes, although the brightness of an incandescent lamp placed in circuit is greatly increased. This indicates that the luminosity of the tube, unlike that of the incandescent lamp, does not depend on the efficient intensity, but on the average intensity which diminishes as the number of tubes is increased. The theoretical consideration of these observations is dealt with at some length. A. E. G.

490. *Bending of Electric Waves round a Large Sphere.* **J. W. Nicholson.** (Phil. Mag. 24. pp. 755–765, Nov., 1912.)—A continuation of work referred to in Abstracts Nos. 382 (1912) and 1323 (1910). The first part of the present paper deals with points near the axis in the region of brightness, it being shown that the preceding investigation does not fail near the axis. The second part gives a general investigation of the shadow. The results render more emphatic the earlier conclusion that the explanation of long-distance radio-telegraphy must be sought elsewhere than in diffraction. T. P. B.

491. *Effect produced by an Obstacle on a Train of Electric Waves.* **H. M. Macdonald.** (Roy. Soc., Phil. Trans. 212. pp. 299–337, Nov. 13, 1912.)—The author applies his previously-obtained integrals of the equations of propagation of electric disturbances in terms of the electric and magnetic forces tangential to any surface enclosing the sources of the disturbances. The effect produced by an obstacle is represented as a distribution of sources throughout the space occupied by the obstacle, and the solution consists in determining this distribution, or, what the author has found to be the same, the determination of the electric and magnetic forces tangential to the surface. The waves incident on the surface may be represented as the effect of a distribution of Hertzian oscillators. The electric and magnetic current distributions at each point of the surface are the same as if that point were in an infinite plane surface coinciding with the tangent plane to the surface of the obstacle at the point. The three cases of perfectly conducting, perfectly absorbing, and imperfectly conducting obstacles are discussed and their respective asymptotic expressions obtained. H. H. Ho.

492. *Current-potential Curves of the Oscillating Spark and the Mechanism of Spark Conduction.* **S. R. Milner.** (Phil. Mag. 24. pp. 709–721, Nov., 1912.)—Current-potential curves of the oscillating spark are obtained by the simultaneous magnetic and electric deflection of the kathode-ray pencil in a Braun tube. The primaries of two induction coils are connected in series. The first coil sends a volley of kathode rays through the tube, while the other simultaneously excites the oscillation circuit. Photographs of the curves are reproduced. When the current and the p.d. between the plates of the condenser are combined, the curves are spirals, which show that, as theory demands, the potentials and currents are damped harmonic curves, differing in phase by 90°. The decrement is more nearly uniform than logarithmic.

Curves connecting current with p.d. across the spark-gap are "crosses," showing an undamped p.d. The potential and current curves deduced are shown in the Fig. As the current passes through zero, the p.d. rises rapidly to a "glow" p.d. of 300 volts, and then falls suddenly to an "arc" p.d. of 35 volts, at which it remains while any measurable current is passing. The arc p.d. increases with spark length, and decreases slightly with high frequency, but the glow p.d. is independent of both. The theory suggests that the difference between the spark and the arc discharge is to be found in the comparative coolness of the instantaneous anode. It is this that gives rise to the glow p.d. Once the initial ionisation of the gap has taken place under the sparking p.d., the surface of the kathode rises rapidly in temperature under



bombardment of the massive positive ions of low penetrating power and emits corpuscles freely, and thus the p.d. falls to the arc p.d. The corpuscles, however, with their greater penetrating power will distribute their energy over a thicker layer of the anode, which will thus not rise to the same surface temperature as the kathode. On reversal, the new kathode is comparatively cool, and cannot supply corpuscles at the necessary rate. The air in the gap, however, is ionised, and thus the conditions for the glow discharge are present, until the surface of the new kathode has risen in temperature. A number of features of the spark are elucidated by the theory, and photographs supporting the theory are given. Incidentally it is mentioned how the apparatus may be used to determine frequencies as high as 2×10^8 per sec.

T. P. B.

493. *Measurement of Damping in Electrical Oscillation Circuit.* **F. Kiebitz.** (Deutsch. Phys. Gesell., Verh. 14. 22. pp. 1016–1022, Nov. 30, 1912.)—Bjerknes' method of determining damping involves the assumptions (1) that the influence of the damping on the frequency is negligible; (2) that the resonance curve is used only in the neighbourhood of the resonance point; (3) that the back-working of the secondary on the primary is negligible. With regard to (3) it is very difficult to determine a small coupling, and,

therefore, it is in many cases uncertain whether Bjerknes' formulæ are applicable or not. In the present paper theory is given leading to formulæ which may be employed without the reservations (2) and (3). T. P. B.

494. *Oscillographic Study of the Singing Arc.* **J. E. Hoyt.** (Phys. Rev. 35. pp. 387–396, Nov., 1912.)—The object of the paper is to discover how the musical note emitted by the arc varies in character as two or more condenser circuits are placed in parallel across the arc. Oscillograph curves are given, showing the currents in the arc and in the condenser circuits. The construction of an acoustic oscillograph is described, which is used to give a record of the note simultaneously with the oscillograms of the currents. In the case of a single shunt circuit, the sound is isochronous with the electrical oscillation, and shows only one harmonic. For more complex shunts it appears that there are harmonics in the note which do not exist in any of the electric circuits. With a complex shunt the note is more likely to correspond to the higher electrical frequency, when the arc is short, but to the lower when the carbons are further apart. T. P. B.

495. *Effect of Magnetic Field on Ionisation Currents.* **W. Duane.** (Le Radium, 9. pp. 342–347, Oct., 1912.)—A complete account of the experiments described in Abstract No. 1542 (1911), the preliminary results being verified. E. M.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

496. *Electric Conductivity of Diamond.* **H. v. Wartenberg.** (Phys. Zeitschr. 13. pp. 1123–1126, Nov. 15, 1912.)—As the result of these experiments it is concluded that diamond up to 1350° has at least a specific resistance of 10^6 ohms-cm. and probably a much greater value. E. H. B.

497. *Electric Conductivity of Thin Films of Dielectric.* **E. Branly.** (Comptes Rendus, 155. pp. 933–939, Nov. 11, 1912.)—With a view to elucidating the action of wireless detectors, the author studies the behaviour of thin films of dielectrics. The substances used are gutta-percha, collodion, mica, celluloid, and paraffin. The thickness of the films varies from 5 μ to 25 μ. The films are placed between a fixed metallic disc and a movable one, which is pressed against the film with varying pressure. All the films exhibit the same behaviour. They all become conducting at a certain pressure, the current through the film being proportional to the e.m.f. When this conductivity has been established, an electric discharge at a distance reduces suddenly the resistance of the film. The electric state of the film is again stable, the current being proportional to the e.m.f. A suitable mechanical shock restores the resistance of the film to its original value. A small contact gives the same results as the disc contact. The dielectric film between two metallic discs is, at suitable pressures, as sensitive as other wireless detectors, and may be used for quantitative determinations. T. P. B.

498. *Surface Conduction of Electricity.* **J. Stock.** (Acad. Sci. Cracovie, Bull. 6a. pp. 635–656, June, 1912.)—Measures the conductivity of nitrobenzol and other liquids with and without the addition of quartz sand to increase its surface. Calculates, on the basis of Helmholtz's theory, the thickness of the electric double layer active in electric osmose. It turns out to be about

20 times the diam. of the molecule. The charge per cm.^{2} of the limiting layer is 1110 e.s. units, which makes the number of monovalent ions per cm.^{2} $2{\cdot}4 \times 10^{12}$, with a distance apart amounting to $6{\cdot}5\ \mu\mu$. This is the same as their mean distance from the wall of the tube. The coefficient of friction between nitrobenzol and glass is 44,000 gm. cm.$^{-2}$ sec.$^{-1}$. E. E. F.

499. *Determination of the International Ampere in Absolute Measure.* **E. B. Rosa, N. E. Dorsey**, and **J. M. Miller.** (Bureau of Standards, Bull. 8. pp. 269–393, June 15, 1912. Electrician, 70. pp. 846–847, Feb. 7, 1913. Abstract.)—This paper describes in full the new current balance constructed at the Bureau of Standards [see Abstract No. 74 (1912)]. The type of balance is similar to that used by Rayleigh in 1884, and since employed by Janet, Laporte, and Jouast, at Paris. The electrical system consists of one pair of fixed coils and one moving coil, and with these (on reversal of a current of 1 amp.) the balancing mass is about 6 gm. To reduce the error due to the heating of the fixed coils a system of water cooling was designed to carry away the heat as fast as generated. To protect the moving coil from outside influences it was enclosed in a water jacket through which water at a constant temperature was passed. To obtain checks upon the work and a final result of greater weight, several pairs of fixed coils have been used, and several different moving coils, with two different radii both in the fixed and in the moving coils. Rayleigh has shown that the ratio of the radii of the coils is the principal term in the constant of the instrument. Very careful measurements were made, therefore, in order to obtain this ratio with high precision. The construction of the balance is described in detail, and the sources of error, *e.g.*, maladjustment, effect of leads, changes in dimensions, errors in measurements of dimensions, and magnetisation of parts are fully considered. The final result is given in two forms : (1) That the e.m.f. of their Weston normal cells at 20° C. was 1·01822 semi-absolute volts [*i.e.* in terms of the international ohm and ampere (10^{-1} C.G.S.)], and (2) the electrochemical equivalent of silver when pure electrolyte is used in a porous pot form of voltameter or a non-septum form, is 1·11804 mgm. per coulomb. F. E. S.

500. *Absolute Measurement of Resistance by Alternating-current Methods.* **A. Campbell.** (Roy. Soc., Proc. Ser. A. 87. pp. 391–414, Oct. 31, 1912.)—A standard mutual inductance of novel type [see Abstract No. 1571 (1907)] has formed the basis for the determination of the unit of resistance in absolute measure by two different methods in both of which alternating current is used. In the first of these, two-phase alternating currents are used. If M is the mutual induction of the inductometer and R is the standard resistance the alternating p.d. on which is balanced by the induced alternating p.d. on the inductometer, then $R = A\omega M/B$, A cos ωt and B sin ωt being the instantaneous values of currents in quadrature. A vibration galvanometer tuned to the frequency of the alternator was used as a detector. The mean result of 8 experiments shows that 1 international ohm $= 1{\cdot}0002_5$ ohm (10^{-9} C.G.S.). In the second method the capacity of a condenser is evaluated in terms of a resistance R and a frequency n by Maxwell's commutator method, and in terms of two resistances (R and P) and a calculated mutual inductance M, by Carey Foster's method. The first method gives $bnKR = a(1-\beta)$, where b and a are the ratio arms, K is the capacity of the condenser, and β a small correction depending on the resistances of the galvanometer, battery, etc. The Carey Foster method gives $PKR = M$ (corrections being neglected), and from the two methods we have $P = Mnb/[a(1-\beta)]$ which

gives P in terms of a mutual inductance and a frequency. Various difficulties having been considered, and especially the variation of capacity due to change of frequency, the final result is given as 1 international ohm $= 1{\cdot}0002_7$ ohms (10^{-9} C.G.S.), a value almost identical with that obtained by the two-phase method. The probable error is given as about 1 part in 10,000.

F. E. S.

501. *The Silver Voltameter.* **E. B. Rosa, G. W. Vinal,** and **A. S. McDaniel.** (Electrical World, 60. pp. 1261–1263, Dec. 14, 1912. Elektrotechn. Zeitschr. 34. pp. 232–234, Feb. 27, 1913.)—An historical review of the work done on the silver voltameter from 1880 to 1908 precedes a description of the authors' investigation at the Bureau of Standards. The results of this investigation are given in 4 papers. In the first two of these the voltameters are described. Some of the kathodes were of platinum and some of gold, and the capacities varied from 125 c.cm. to 350 c.cm. The types of voltameters used were: (1) with filter paper, (2) with the porous cup, (3) with a glass cup under the anode, and (4) the siphon form. A difference in the silver deposits of about 40 parts in 100,000 was found between the filter-paper voltameter and the porous-cup form, the latter giving the lower value. It was found that a silver nitrate solution was contaminated by means of filter-paper and the contaminated solution gives the heavier deposit on electrolysis. All kinds of paper produce the same effect as do also many organic materials. Striation in the deposits could be produced only by adding strong reducing agents to the electrolyte, and since the filter-paper deposits were striated it was evident that cellulose must act as a strong reducing agent. Further experiments led to the conclusion that the reducing action on $AgNO_3$ solutions takes place through the formation of oxycelluloses, probably decomposing into furfuraldehyde or some of its homologues. Since pure cotton cellulose is a hexopolyose, and not generally considered as yielding furfuraldehyde, careful tests were made which showed it to be present. A pure electrolyte containing 0·001 per cent. of polymerised furfural when electrolysed gave a strongly striated deposit similar to that of the filter-paper voltameter. The authors have formulated a theory to account for the changes from the crystalline deposits of pure solutions to the non-crystalline and striated deposits of the impure solutions. It appears that the first essential condition for striations is the presence of a colloid that will be deposited on the kathode. The second essential condition is a motion of the liquid over the kathode surface. F. E. S.

502. *Resistance Coils for Alternating-current Work.* **H. L. Curtis** and **F. W. Grover.** (Bureau of Standards, Bull. 8. pp. 495–517, Nov. 1, 1912.)—A theoretical discussion is given to show the conditions which must be fulfilled in the construction of resistance coils in order that the phase angle shall be small and the change of resistance with frequency negligible. These principles are applied to the design of coils of different values, and specifications are given for the construction of coils of different denominations from 0·1 to 10,000 ohms. F. E. S.

503. *Silver Voltameter.* **A. Boltzmann.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1051–1074, June, 1912.)—Experiments were made to compare the relative weights of the silver deposits in voltameters in which the original kathode surfaces were sometimes clean platinum and sometimes platinum coated with silver. The deposits were from 1 to 3 gm. and those on a clean Pt surface were about 0·1 mgm. heavier than the deposits on a surface

previously coated with silver. A still heavier deposit was obtained when the area of the clean Pt kathode was reduced by one-half. The author concludes that it is best to make the deposit on a kathode previously coated with silver. Other experiments were made to detect the influence, if any, of the anode liquid; no disturbing influence was found. Further, the mass of the deposit was found to be the same when the voltameter was exposed to bright sunlight as when kept in the dark. F. E. S.

504. *Measurement of the Inductances of Resistance Coils.* **F. W. Grover** and **H. L. Curtis.** (Bureau of Standards, Bull. 8. pp. 455–485, Nov. 1, 1912.)—In this paper is treated the measurement of the "effective inductance" of non-inductive resistance coils for use in alternating-current bridges and in potentiometer circuits where it is desired to know the phase-angle. The latter depends on the inductance and the capacities between the windings and between the various parts of the coil and the earth. The "effective inductance" is that value of inductance which would produce the observed phase-angle. The measurements with coils of low resistance are best made by means of a substitution method, using as a standard of reference a resistance of the same nominal value as the unknown, but such that its inductance may be calculated from its dimensions. Both parallel wires and circles have been used. To obtain small variations of resistance, with negligible change in inductance, wires of equal dimensions but of different conductivities were substituted one for the other. For resistances of 1000 ohms and upwards the capacity of a parallel-wire standard with respect to the earth becomes important. Attention is called to the fact that the usual formula for the capacity of such a standard applies only when the potential of one wire is as much above the earth potential as the other is below it. A method is given for adjusting the potentials of the bridge to their correct values, and this, having been accomplished, the substitution method gives accurate results with resistances at least as high as 10,000 ohms. Two methods are given for the measurement of the effective inductances of coils in those cases where it is impracticable to construct primary standards but these are not so precise. F. E. S.

505. *The Mutual Inductance of Two Coaxial Circular Currents.* **H. Nagaoka.** (Phys. Soc., Proc. 25. pp. 31–34; Discussion, p. 34, Dec., 1912.)—Methods are given for the rapid calculation of the mutual inductance of two coaxial circular currents. Maxwell's first formula is converted into theta-functions and then expanded in a Jacobian q series. The logarithmic values of this series have been tabulated in a previous paper by the author. When the circles are near to one another a series for M is given in terms of q_1, where q_1 is the complement of q. In this paper Maxwell's second formula is treated in a similar way. A table of the values of these series formulæ, computed by Tishima to seven decimal figures, is given. The chief advantages of this table are that nearly all practical cases are included within a short range of the argument, and the calculation is simple, as the numbers in the difference columns are small. By the help of these tables and series the mutual inductance between two coaxial currents can be easily computed to a high degree of accuracy. A. R.

506. *Resistance Measurements of High Precision.* **F. E. Smith.** (Phil. Mag. 24. pp. 541–569, Oct., 1912. From the National Physical Laboratory.)—Certain new bridge methods of measuring with high precision the resistance

of a platinum thermometer, or similar resistance, are described. The sources of error due to the heating effect of the current and the heating effect in the bridge arms are considered, and various arrangements of the resistance measuring apparatus designed to secure accuracy are fully discussed.

J. J. S.

507. *Four-terminal Conductor and the Thomson Bridge.* **F. Wenner.** (Bureau of Standards, Bull. 8. pp. 559–610, Nov. 1, 1912.)—In low-resistance standards capable of carrying large currents, the surfaces of the contacts through which the current enters and leaves must be large. In many cases the resistance depends, to some extent, on the manner in which the current loads are attached. In alternating-current measurements it is also necessary to know the inductance. The present paper points out the conditions which must be fulfilled in order that the resistance may be definite, or both the resistance and inductance be definite. The design of low-resistance standards is discussed, and the theory of the Thomson bridge using linear four-terminal conductors is given. [See also Searle, Abstract No. 475 B (1910).]

F. E. S.

508. *Hall-effect in Metals at Low Temperatures.* **H. Alterthum.** (Ann. d. Physik, 39. 5. pp. 933–960, Dec. 5, 1912.)—An experimental and theoretical research of which the chief results may be summarised as follows :—(1) In extension of previous data the Hall-effect was investigated at various temperatures down to that of liquid hydrogen. The temperatures actually used were (*a*) room temperature 291° K., (*b*) a mixture of solid CO_2 and ether at 194° K., (*c*) liquid air 83° K., and (*d*) liquid hydrogen at 20° K. (2) The curves for the Hall-effect and temperature have a regular form ; Cu, Cd, Sb, Au show maxima, Al and Pt minima. (3) The ferromagnetic bodies Fe and Ni decrease to the temperature of liquid air, and then assume a constant value. (4) The previous attempts to bring the Hall-effect into agreement with electron theory by explaining it as due to the action of the field on free electrons could not account successfully for the difference of the signs. (5) Also at very low temperatures, since the conductivity (and therefore the speed of the electrons) there increased, the Hall-effect should have increased, which is not the case. (6) The present experimental data with their maxima and minima point rather to the existence of some complicated relations lying at the root of the Hall-effect. (7) At the absolute zero the relations are essentially simplified. The endeavour is made to bring the Hall-effect at absolute zero into relation with diamagnetism. (8) The curves with maxima belong to diamagnetic metals, those with minima to paramagnetic ones. (9) This relation held for Cu, Au, and Ag, whose Hall-effects have the negative sign. (10) No such relation could be found for Zn, Cd, Sb, Te, and Pb, nor for the magnetic metals (except Fe and Co), whose Hall-effects have the positive sign. (11) It is also found that the diamagnetic susceptibilities of these metals are not independent of the temperature. [See Abstract No. 443 (1910).] E. H. B.

509. *Three-plate Condenser and Dielectric Constants of Solid Bodies.* **E. Grüneisen** and **E. Giebe.** (Phys. Zeitschr. 13. pp. 1097–1101 ; Discussion, p. 1101, Nov. 15, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—The determination of the dielectric constant of a solid body by placing a plate of the substance between the two plates of a condenser can only be made accurately if special precautions are taken. The "edge" correction and the capacity of the condenser with respect to the

earth must both be taken into consideration. A three-plate condenser in which the two outer plates are earthed is to be preferred to a two-plate condenser because the capacity is independent of the surroundings, and the "edge" correction is proportionately smaller. A formula is given for the calculation of the capacity of a three-plate condenser, and this formula is verified by experiment. T. P. B.

510. *Volta-effect.* **F. Sanford.** (Phys. Rev. 35. pp. 484–489, Dec., 1912.)—Finds by experiments that the Volta-effect is not due to any electrolytic action between the opposed metals, but different metals when in contact with the earth or with the inside of the same hollow conductor may be at different potentials relative to each other. E. H. B.

511. *Thermo-electric Properties of the Iron-Nickel-Carbon System.* **E. L. Dupuy** and **A. Portevin.** (Comptes Rendus, 155. pp. 1082–1085, Nov. 25, 1912.)—The authors have determined the thermal e.m.f. against lead of alloys containing 0·07 to 1·05 % carbon and 0 to 30 % Ni, the residue being iron except for impurities which never exceeded 0·25 %. Measurements were made between −78·5° and 0° C. and 0° and 100° C. on samples as made, after annealing, and after hardening. The results, plotted in the form of concentration-e.m.f. curves show a minimum at the martensite-austenite change-point. It is suggested to use the method as one to control the results of chemical analysis. F. C. A. H. L.

512. *Construction and Constants of a Rectangular Galvanometer.* **A. Ferguson.** (Phil. Mag. 24. pp. 788–804, Nov., 1912.)—The field at any point in the plane of a rectangular coil carrying a current i can be expressed in the form $F = i(1/p_1 + 1/p_2 + 1/p_3 + 1/p_4)$, where p_1, p_2, etc., are the lengths of certain perpendiculars. If i is measured by means of a current balance, F can be obtained in terms of it and $\Sigma(1/p)$. The author then enters into a mathematical discussion and shows that for a rectangular coil of given length of wire the square is the least advantageous form but is better than the circle as regards field intensity, at its centre of symmetry. He then shows that, for a rectangular single-layer coil of dimensions, $c = 21$ cm. and $d = 30$ cm., and with breath of winding of 1 cm., the field at the centre of the coil is $4i'cd \cdot \sqrt{(c^2 + d^2)}$, the error introduced in neglecting the breadth being of the order of 1 part in 10,000. He points out that an important error may arise through irregularities in the winding of the turns and shows how to calculate the errors due to slight deviation from trueness in the side of a square. The error due to curvature at the corners is negligible. To test the galvanometer he measures H, and obtains results which are in good agreement with those secured with the aid of a Helmholtz galvanometer having cylindrical coils. W. C. S. P.

ALTERNATING CURRENTS AND MAGNETISM.

513. *Multi-lamellar Magnetic Screens.* **W. Esmarch.** (Ann. d. Physik, 39. 6. pp. 1540–1552, Dec. 23, 1912.)—The galvanometer of Du Bois and Rubens is provided with a triple shield, and that used by Nichols and Williams with a quadruple screen [but see Abstract No. 291 (1909)]. The author describes experiments on the effect of multiple screens made from alternate layers of iron wire and cardboard. The method of testing was by means of two opposed current circuits round a needle, one circuit within and

the other outside the screen. The wires employed to form the screens were of Russian and Swedish iron with a permeability between 100 and 116. The results are given in the form of curves and tables. These show that the screening increases with the number of layers, but very slowly after a certain number of layers is reached. It is advantageous to use cardboard of the same thickness as the wire employed, and the permeability of the iron wire has a great influence on the amount of screening obtained. In some cases over 60 layers of iron wire were employed. G. E. A.

514. *Theoretical Contribution to Methods of Measuring the Hall-effect.* **F. Kolácěk.** (Ann. d. Physik, 39. 6. pp. 1491–1539, Dec. 23, 1912.)—A thin rectangular plate of cast bismuth has two thick copper wires connected to its short sides, and a single thin copper wire (Hall electrode) to the middle of one of the long sides, whilst the opposite long side has a pair of electrodes at equal distances from the midpoint of that side. The pair of points is connected through a rheostat or resistance box, and the galvanometer is placed between the rheostat and the single electrode. The galvanometer deflection due to the Hall-effect depends on the distance of the pair of electrodes from the middle of the side, and is reduced by one-half when the electrodes are at the ends of the long side. This presents a mathematical problem in conduction with which the rest of the paper is concerned. G. E. A.

515. *Thermomagnetic Study of Steel.* **S. W. J. Smith.** (Phys. Soc., Proc. 25. pp. 77–81, Dec., 1912.)—Use is made of the fact that there is, for simple ferromagnetic substances, a field for which the permeability variation with temperature is comparatively small except in the neighbourhood of the critical temperature. In such fields there is a very clearly marked peak in the permeability-temperature curve. This peak is exhibited by the carbide of iron (cementite) which exists in annealed carbon steels, and in a particular steel containing 0·85 per cent. of carbon there was a sharply marked maximum of permeability at 210° C. It is considered possible to determine the percentage of carbon in a given steel by means of this thermomagnetic property. G. E. A.

516. *Changes in Iron and Steel at High Temperatures.* **K. Honda** and **H. Takagi.** (Mathematico-Physical Soc., Tōkyō, Proc. 6. 20. pp. 294–306, Oct., 1912.)—It has been determined metallographically that α iron, the strongly magnetic form, is converted into β iron, only weakly magnetic, at 770° C. and into the γ, or most feebly magnetic, form at 890° C., and that similar changes occur in mild steels. Unlike the processes of melting and boiling, these changes do not take place at one definite temperature but within a certain definite temperature-interval. Magnetic tests have also shown that γ iron is converted into δ iron at 1280° C. Although a change in state necessitates alteration in one or more properties of a body it does not follow that the whole of the properties are affected by the change. Experiments in which magnetic permeability, temperature, and time have been observed simultaneously, have been carried out on Kahlbaum's pure iron, steels containing from 0·14 to 1·5 % carbon and on a steel containing 5 % tungsten and 0·6 % carbon. The results show that the β—α or α—β change occurs over a small interval of temperature which increases with increase of carbon. The evolution of heat during the β—α or γ—α change cannot be observed in the case of steels. Eutectic separation of iron from solid solution is accompanied by a much larger evolution of heat and by a

discontinuity in the increase of magnetic permeability. The temperature of the eutectic change is 30—40° higher on heating than cooling. Recalescence results from the separation of iron from the solid solution and not from the β—α or γ—α change in the iron. F. C. A. H. L.

517. *Magnetisation of Heusler Alloys as a Function of the Temperature.* **P. W. Gumaer.** (Phys. Rev. 35. pp. 288–305, Oct., 1912.)—The ballistic method employed by Weiss and Stifler was used to determine the saturation value of the magnetisation intensity for two ellipsoids containing about 62 per cent. of copper. A molecular theory of magnetism is developed, from which the variation of specific intensity of magnetisation with temperature could be expressed. The experimental and theoretical curves agree above 200° C., and the critical temperature was 310° C. Chilling the specimens from near the melting-point causes the experimental curve to follow the theoretical curve to a lower temperature than before, and the molecular field was found to be of the same order of magnitude as that for nickel. The fundamental equation on which the theory is based has been derived mathematically, thereby making the former analogy to the gas theory unnecessary. G. E. A.

518. *Coefficient of Magnetisation of Water and Oxygen.* **P. Weiss** and **A. Piccard.** (Comptes Rendus, 155. pp. 1234–1237, Dec. 9, 1912.)—The magnetisation of water was measured by Quincke's method. First the magnetisation of a concentrated solution of chloride of manganese was measured and subsequently compared with water by noting the attraction or repulsion of an electromagnet on a quartz tube filled successively with hydrogen, water, and the solution. Susceptibility per unit mass $\chi = -0{\cdot}7193 \times 10^{-6}$ at 20° with a temperature coefficient $\alpha = +0{\cdot}00013$ in this neighbourhood. The susceptibility of oxygen was measured by comparing the height of water in a magnetic field under oxygen with that under hydrogen. For dry oxygen at 760 mm. and 20° :—Susceptibility per unit vol $K = +0{\cdot}14073 \times 10^{-6}$; for air under same conditions $K = +0{\cdot}02941 \times 10^{-6}$; oxygen per unit mass $\chi = +1{\cdot}0568 \times 10^{-4}$. Considering the two atoms of oxygen as a rigid system as the specific heat requires, on calculating the magnetic moment of the molecule we find $u = 7{\cdot}007$ magnetons per atom ; the magneton 1123·5 being the common measure of the atomic moments of iron and nickel observed in liquid hydrogen. Considering the molecule as a non-rigid system $u = 9{\cdot}90$ per atom. J. M.

519. *Constitution of Water.* **A. Piccard.** (Comptes Rendus, 155. pp. 1497–1499, Dec. 23, 1912.)—The author has observed that the susceptibility of water is 0·75 % greater at 100° than at 0° [see preceding Abstract]. Since generally the susceptibility only changes with change of state, he assumes that water consists of two substances in equilibrium, the less dense having the density of solid ice. From density measurements the percentage of pure water and ice are calculated at different temperatures. The decrease in susceptibility for the temperature interval 100°–0° being due to the formation of a definite amount of ice, the sudden decrease on solidification can be calculated. This is 1·9 % ; observed, 2·4 %. The agreement between the curves for the composition of water from the volumetric and from the magnetic properties is very close. J. M.

520. *Magnetic Effect of Oceans.* **A. Berget.** (Comptes Rendus, 155. pp. 1198–1200, Dec. 9, 1912.) — Reference is first made to Wilde's

Magnetarium, described in 1890, in which the earth's magnetism was represented as composed of two actions: that of the central nucleus and that of the crust. This is considered in relation with Lippmann's theory of the distribution of matter at the earth's surface, and a diagram given suggesting a difference in level of the nucleus material, which is supposed to be strongly magnetic. The portions in excess are arranged under the ocean areas, and would have some such effect as the metallic plates in Wilde's apparatus. C. P. B.

521. *Magnetic Disturbances, Earth Currents, and Solar Eruptions.* **J. Bosler.** (Journ. de Physique, 2. Ser. 5. pp. 877–891, Nov., 1912. Paper read before the Soc. franç. de Physique, May 3, 1912.)—Summarising the results of an examination of the Greenwich magnetic curves it is shown that as the first movements of a magnetic storm are generally in the same direction with regard to the local meridian, the direct cause of the perturbations must be terrestrial, and it will move with the earth. It has usually been noticed that magnetic perturbations have been synchronous with large variations of the intensity of earth currents. Plottings of the current and magnetic field variations from the records of Saint-Maur and Greenwich indicate a concentration of these factors in two definite orientations, approximately differing by 90°; this suggests some similarity of effect to that exerted by a current in a wire on a magnet pole brought near the circuit. Moreover the general results of most observers indicate that the magnetic disturbances are more related to the solar features exhibiting rapid changes, rather than to any particular large spot or prominence which may be visible at the time. The magnet disturbances would thus be regarded merely as the variations of earth currents always present, but only of special notice when rendered of unusual magnitude by the influence of solar induction. C. P. B.

RADIOLOGY AND ELECTROPHYSIOLOGY.

522. *Spark Inductors and Röntgen Tubes.* **F. Dessauer.** (Phys. Zeitschr. 13. pp. 1101–1104; Discussion, pp. 1104–1105, Nov. 15, 1912. Paper read before the 84. Naturforscherversamml., Münster, Sept., 1912.)—The method of breaking the primary circuit by means of melting a metallic wire so that a large current acts for a small period of time is further described [see Abstract No. 272 (1910)]. It is shown that in about 1/25 sec. after closing the primary circuit both the current and the magnetic field attain the required maximum, and that in a little over 1/1000 sec. later the primary current of more than 250 amps. is reduced to zero, and this without having a condenser in the circuit. The use of the apparatus for studying the heart's action, etc., is discussed. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

523. *Chemically Active Modification of Hydrogen.* **I. Langmuir.** (Amer. Chem. Soc., Journ. 34. pp. 1310–1325, Oct., 1912.)—When a tungsten wire is heated at 1302–2500° K. in hydrogen at very low pressure (0·001–0·002 mm.), the hydrogen slowly disappears. With nitrogen or CO such disappearance never occurs below about 2200° K., and seems to be an electrical effect, whilst with hydrogen it appears to be purely thermal. There is a distinct fatigue effect, but the substitution of fresh wire does not restore the action. The hydrogen is not absorbed by the wire but is deposited on the glass, especially where the latter is cooled by liquid air. If the wire is allowed to cool and the liquid air then removed, ordinary hydrogen is liberated which will not recondense when the liquid air is replaced. If this gas is pumped out and oxygen admitted, the oxygen will disappear and in its place a small quantity of hydrogen will appear. With platinum and especially with palladium wires these effects are much more marked. These phenomena are not due to the presence of finely-divided metal on the surface of the glass. When phosphorus is present on the bulb and hydrogen is introduced and the wire heated, the hydrogen disappears and hydrogen phosphide is formed. The theory is advanced that the hydrogen dissolves in the material of the wire in the atomic condition, and that some of these atoms, leaving the wire, do not meet other atoms (owing to the low pressure) but diffuse into the tube cooled by liquid air or become adsorbed by the glass, and thus remain in the atomic condition and retain all the chemical activity of the atoms. T. H. P.

524. *Influence of Radium Radiations on Glass and certain Minerals.* **S. Meyer** and **K. Przibram.** (Akad. Wiss. Wien, Ber. 121. 2a. pp. 1413–1418, July, 1912. Communication from the Inst. f. Radiumforschung.)—Fluorspar on exposure to β-rays was found to turn to a blue colour and to possess the property of being thermo-luminescent at a temperature as low as 60° C. Protracted heating reduced the fluorspar to normal condition. As kuuzite shows similar effects the authors consider that all thermo-luminescent bodies have their temperature of thermo-luminescence reduced by exposure to β-rays. Different glasses exposed to β-rays either assume a brown colour or a violet colour. Some bottles of radium solution were coloured brown where the liquid was in contact with the glass and blue above the surface, the latter colouration being probably due to the radium emanation. Brown-coloured glass heated carefully thermo-luminesces with a greenish light like that due to X-rays, and afterwards becomes violet. With further heating up to the softening point the violet colour gradually disappears with no further luminescence. By exposing either brown-coloured glasses or uncoloured glasses of the same type to ultra-violet radiation a pale yellow colour is the result. Violet-coloured glasses (due to β-radiation) are, however, little influenced by ultra-violet light. The authors do not consider that the theory that the colourations are due to solid solutions of Mn, Fe, etc., is sufficient to account for all the results, although no definite theory is put forward. Some interesting results on the photoelectric effects of powdered substances after exposure to β- and γ-rays were observed. Fluorspar which has become fatigued rapidly recovers a strong photoelectric activity after an

hour's exposure to the β- and γ-rays, whereas it does not recover so rapidly when left alone in the dark. Further, the recovered effect is stronger than the natural effect, but with lasting exposures its photoelectric fatigue proceeds quicker. Similar results were obtained with kunzite. Glass was also found to be photoelectric after exposure to β- and γ-rays, the effect falling off only slowly with continued exposure to the ultra-violet light. E. M.

525. *Size of the Molecule of Metals in Solid Solutions.* **M. Padoa** and **F. Bovini.** (Accad. Lincei, Atti, 21. pp. 708–713, Nov. 17, 1912.)—Experimenting with alloys of Sn-Cd-Bi, the authors have compared the compositions of the original molten alloys, of crystals deposited therefrom during cooling, and of the residual mother-liquor, showing that the concentration of Cd in Sn in the solid state approximates closely to that in the liquid state, so that Cd in the solid state is also monatomic. W. H. Si.

526. *The Chemical Method for the Study of Alloys.* **A. Portevin.** (Rev. de Métallurgie, 9. pp. 884–890, Nov., 1912.)—This is one of the oldest methods for the study of the constitution of alloys, and consists in isolating one constituent by solution of the others in suitable reagents and subsequently analysing the residue. Hence the method has also been called the "method of examination of residues." After dealing with the common objections to the method such as lack of uniformity of composition of the reagent chosen, etc., the author points out two further difficulties, viz. (1) the entrapment of liquid in the primary crystals formed during solidification, and (2) the envelopment of the primary crystals by a definite compound formed by a reaction between the crystals and the surrounding medium subsequent to the beginning of crystallisation. It is therefore advisable to make a preliminary micrographic examination of alloys intended for study by this method. F. C. A. H. L.

527. *Platinum-Aluminium Alloys.* **M. Chouriguine.** (Rev. de Métallurgie, 9. pp. 874–883, Nov., 1912.)—The constitution, structure, and properties of a complete series of these alloys have been studied. To prevent oxidation the metals were melted under lithium chloride in a magnesia crucible heated in an electric furnace. The metals combine with the liberation of a considerable quantity of heat, and on account of their differences in density there is a tendency towards liquation. The thermal diagram shows a eutectic point at 9 % Pt and 639° C., and three discontinuities between this point and the solidification point of Pt. It appears probable that the compounds $PtAl_2$ and $PtAl_3$ are formed. On dissolving alloys containing between 10 and 70 % Pt in 5 % hydrochloric acid a crystalline residue of the composition corresponding to $PtAl_3$ is obtained. Microscopic analysis confirms these views. Between 70 and 90 % Pt the alloys appear golden-yellow under the microscope, and above 70 % Pt a new microconstituent makes its appearance. Solution of these alloys yields a residue containing 90 % Pt, which does not correspond to any simple formula. F. C. A. H. L.

528. *Copper-Zinc-Nickel Alloys.* **L. Guillet.** (Comptes Rendus, 155. pp. 1512–1514, Dec. 23, 1912.)—The author has resumed his work on the substitution of zinc in brasses by other metals [Abstract No. 1319 (1906)], and finds that the coefficient of equivalence of nickel lies between —1·1 and —1·4. An alloy containing 56·7 % Cu, 39·7 % Zn, and 3·4 % Ni has a micrographic value equal to 60 % Cu, and a calculated fictitious value equal to 60·4 % Cu.

Compared with those of brasses containing 60 and 56·7 % of copper respectively its mechanical properties are as follows :—

	Nickel Alloy.	60 per Cent. Cu Brass.	56·7 per Cent. Cu Brass.
Tensile strength, kg. per sq. mm.	47·2	35	40
Yield " " " " "	15·3	12	12
Elongation, per cent.....	42·0	30	10
Reduction of area, per cent.....	51·7	30	15
Shock test on notched bar, ρ	18	10	4
Ball hardness, Δ	97	70	85

Therefore addition of nickel to certain alloys of copper and zinc not only increases the copper-value of the alloy, but at the same time effects a considerable allround improvement in mechanical properties.

F. C. A. H. L.

529. *Notes on Ruff's Carbon-Iron Equilibrium Diagram.* **H. M. Howe.** (Amer. Inst. Mining Engin., Bull. No. 71. pp. 1181–1225, Nov., 1912.)—The author discusses at some length the conclusions arrived at by Ruff [see Abstracts Nos. 1406, 1619 (1911)] with regard to the iron-carbon system. Further experiments by the author and others show that graphitisation of cementite takes place at temperatures much lower than Ruff's limiting temperatures. A simpler theory is put forward to the effect that the true eutectic temperature is the governing one ; that such undercoolings as occur are undercoolings below, and such recalescences as occur are attempts to reach, the true eutectic temperature. F. C. A. H. L.

530. *Notes on Titanium and its Cleansing Effect on Cast Iron.* **B. Stoughton.** (Amer. Inst. Mining Engin., Bull. No. 71. pp. 1245–1275, Nov., 1912.)—The history, occurrence, physical and chemical properties, and manufacture of titanium are briefly described. On a commercial scale the manufacture of pure titanium is not possible, but by smelting titaniferous iron ore with carbon in an electric furnace ferro-titanium containing up to 15 % Ti can be prepared, while iron alloys containing up to 25 % Ti can be prepared by the "Thermit" method. Experiments made on cast iron showed that addition of ferro-titanium to the cupola had no improving influence, but by correct addition to the ladle the transverse strength can be increased by from 30 to 50 %. The max. effect appears to be obtained with about 0·10 % Ti. F. C. A. H. L.

531. *The Relation of Osmotic Pressure to Temperature.* **W. F. Magie.** (Phys. Rev. 35. pp. 272–275, Oct., 1912.)—The relation of osmotic pressure to temperature may be expressed by the formula $p = a\theta(\log\theta - 1) + b\theta + e$, in which b and e are quantities which are functions of the concentration of the solution, but are independent of the temperature θ. In this formula $-a\theta + e = l$, the heat of dilution of the solution. In the case of aqueous solutions of sodium chloride in water, values calculated by means of this formula with the help of experimental data for ordinary temperatures, agree with those obtained by Kahlenberg for the boiling-point. This is regarded as a satisfactory confirmation of the formula, and especially of the view that the quantity a is independent of the temperature. T. M. L.

532. *Nature of Electrical Colloid Synthesis.* **C. Benedicks.** (Ark. för Mat. Astron. och Fysik, Stockholm, 8. 7. pp. 1–31, 1912.)—The object of the present investigation was to decide whether the formation of colloids by Svedberg's and Bredig's methods is an electrical or thermal phenomenon. Examination of the surfaces of the electrodes of different metals, when an arc was made for a very short time—in some cases only one spark was passed—by Svedberg's method, showed that the surface was covered by a number of craters, which could have been formed by the local melting of the electrode; the surface tension then draws the fused metals outwards and forms a crater. It was found possible to imitate the appearance of the electrodes by blowing a gentle stream of hot air through a narrow tube against a surface of asphalt or of paraffin wax, thus supporting the idea that the phenomena observed are thermal. It would follow that the disintegration of the electrodes, with the formation of a colloidal solution, is due to the liquid streaming against the molten metal after the cessation of the arc and breaking it up into globules. The colloidal particles should therefore consist of small spheres, and the microscopic examination of a deposit which had settled out of a particularly stable solution of colloidal iron in the course of a year confirmed this, none of the particles having a diam. greater than 5 μ. Similar results were obtained with colloidal particles of brass, bismuth, and lead. The formation of metal colloids being a thermal phenomenon, it follows that the amount of disintegration of the various metals will depend (1) on their latent heat of fusion, and (2) on their conductivity towards heat. The order in which the metals have been arranged by Svedberg, with respect to the amount of disintegration, agrees with this. T. S. P.

533. *Iron-Carbon System.* **O. Ruff.** (Zeitschr. Elektrochem. 18. pp. 761–764, Sept. 1, 1912.)—The author criticises Smits's discussion [Abstract No. 1468 (1912)] of his work on the iron-carbon system [Abstract No. 407 (1912)]. Generally speaking, the results of the two workers are in good agreement but the author points out that Smits's thermodynamical conclusions as to the meaning of the line BDHY [Abstract No. 407 (1912)] are quite erroneous.
F. C. A. H. L.

534. *Notes on the Metallography of Alloys.* **W. Campbell.** (Amer. Inst. Mining Engin., Bull. 72. pp. 1381–1406, Dec., 1912.)—The author describes some points concerning the constitution of alloys of lead-antimony-tin, of tin-antimony-copper, and alloys with a zinc base used as bearing metals. Tables are given showing the compositions of alloys used in practice, and their structures are illustrated by some excellent photomicrographs.
F. C. A. H. L.

535. *Microstructure of Iron and Steel.* **W. Campbell.** (Amer. Inst. Mining Engin., Bull. 72. pp. 1357–1380, Dec., 1912.)—The importance of metallography to the engineer lies in the possibility of identifying certain microstructures with certain mechanical properties, and with this object the author has set forth the main features of the structures of wrought irons, mild, medium, rail, high-carbon, and alloy steels. Typical micrographs of good and faulty materials illustrate the paper. F. C. A. H. L.

536. *Viscosity and Fluidity.* **E. C. Bingham.** (Phys. Rev. 35. pp. 407–433, Dec., 1912, and 1. (2nd Series) pp. 96–123, Feb., 1913.)—A summary of the results hitherto obtained [compare Abstracts Nos. 716 and 1743 (1911), 104 (1912)]. T. S. P.